Western Engineering

VOL. 3 SAN FRANCISCO, NOVEMBER, 1913 NO. 5

PUBLISHED MONTHLY BY THE WESTERN ENGINEERING PUBLISHING CO. AT 420 MARKET STREET, SAN FRANCISCO.

Entered as second-class matter, June 1, 1912, at the post-office at San Francisco, California, under Act of March 3, 1879

Telephone Kearny 4777. Cable Address: Pertusola. Code: Bedford McNeill (2 editions).

BRANCH OFFICES:

CHICAGO—734 Monadnock Building. NEW YORK—Woolworth Building.
LONDON—The Mining Magazine, 819 Salisbury House, E.C.

ANNUAL SUBSCRIPTION:

United States and Possessions, and Mexico..... $3
Other Countries in Postal Union 4

CHARLES T. HUTCHINSON, Editor L. A. GREENE, Business Manager H. L. QUIGLEY, Advertising Manager

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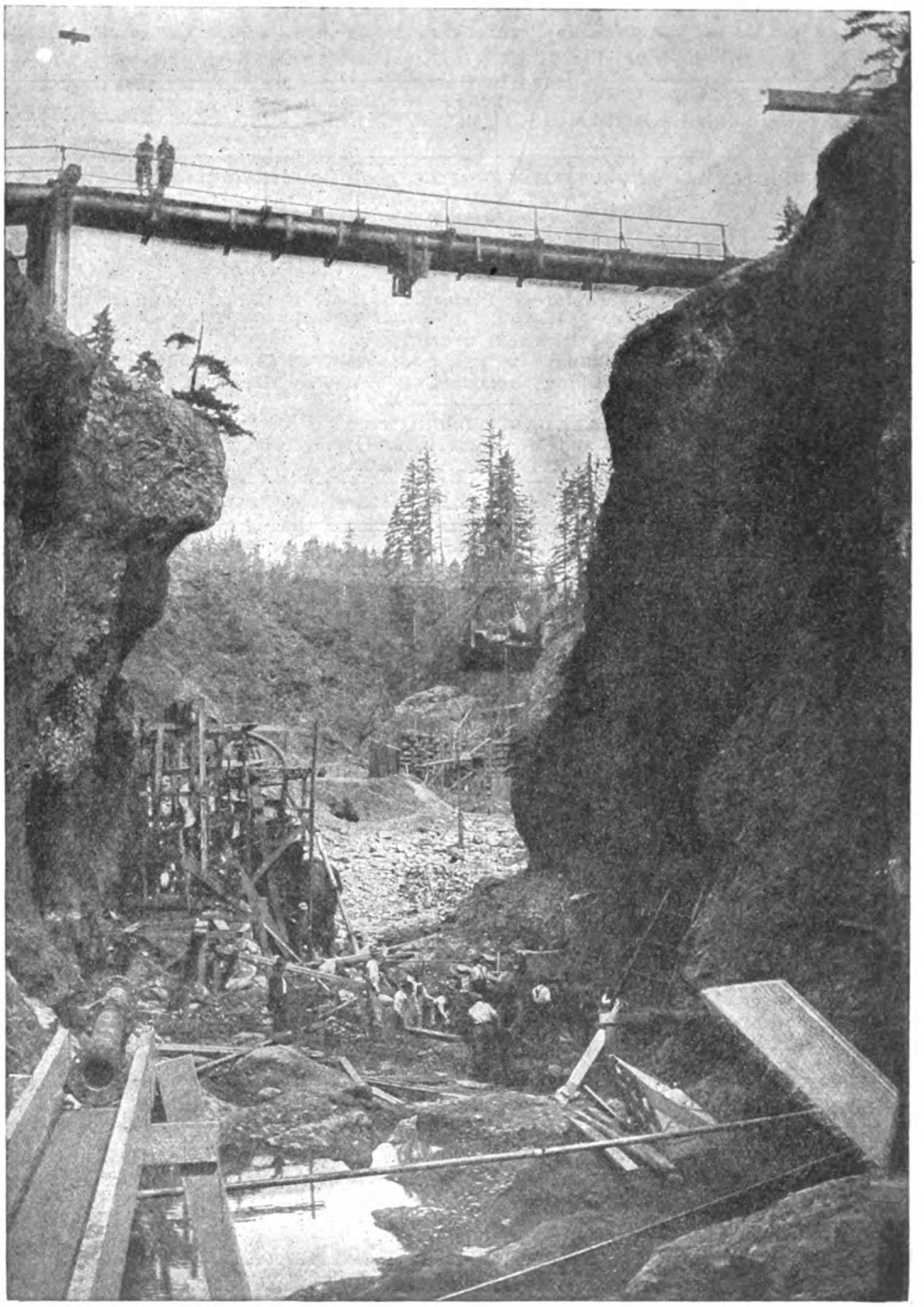

VIEW OF DAMSITE FOR CONDIT PLANT, NORTHWESTERN ELECTRIC COMPANY. (See page 339.)

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EDITORIAL

ARRIVAL of Mrs. Pankhurst in the United States has not thus far affected the price of explosives.

COMPLETION of the Hangman Creek bridge is an event of much importance to the residents of Spokane. This bridge is a reinforced concrete structure consisting of seven arches about 150 feet centres. The total length of the bridge is 1020 feet and the height is 150 feet at its maximum point above Hangman creek. A total of 35,000 cubic yards of concrete was required for its construction, or about 10,000 cubic yards more than was used for the Monroe Street bridge. Approximately two years time was required to complete the work, which has been carried through not only without loss of life but without even a serious accident. The total cost was $120,000, the design and general supervision for the city being the work of Mr. Morton Macartney, city engineer, while Mr. J. E. Cunningham was the contractor.

ONE of the many beneficial results of the western tour recently completed by Mr. Franklin K. Lane, Secretary of the Interior, has been a better understanding of the needs of the farmers of irrigated lands. Mr. Lane has already shown in many ways his sympathy with the needs of the West, and his trip has evidently brought about a broader understanding of the many problems that remain to be solved. It has been stated that $35,000,000 will be required to complete the various irrigation projects now under process of development by the Reclamation Service. Of this sum, $20,000,000 has been provided by a bond issue, $10,000,000 will be secured through the sale of lands, and $5,000,000 will be paid in rentals by homesteaders. Mr. Lane will recommend the authorization of a bond issue of $100,000,000 for the extension of this work. In discussing the subject in a recent interview, Mr. Lane is quoted as having said, "The farmers on our irrigation projects must have a longer time in which to pay for their water rights. They must have more education in the use of water, so there will be less waste, and methods must be devised by which either through the banks or by a system of rural credits money can be raised for the introduction of cattle on the farms. As it is now, the farmers are producing raw products which yield but little, whereas they should be producing a more finished product. Instead of selling alfalfa at $5 to $6 a ton, they should be turning it into meat, which would more than double the value of the alfalfa. Great interest is being taken throughout the West in the development of coöperative agencies by which the farmer can sell directly to the consumer. There is an abundance of rich land which may be irrigated, and we could properly expend in the next few years this $100,000,000 in the developing of small irrigated farms. The people are land hungry. Less than 2 per cent of our public land on irrigation projects is unoccupied. There is no denying the fact that the people in the West feel that we in Washington have not a clear enough perception of their condition and needs. I expect to meet this need not only by keeping in touch with the people of the West by conferences called here, but by spending sev-

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eral months out of each year in that section of our country."

STATISTICS compiled by the *Oil and Gas Journal*, showing the quantity of gasoline manufactured from casing-head gas in the California field form an interesting commentary on the rising importance of this branch of the oil industry. The total quantity produced by this method at present is 16,950 gallons per day, and the daily output of each company in gallons is as follows:

Puente Oil Co., Puente	450
Pacific Gasoline Co., Brea Canyon (two plants)	4,000
Union Oil Co., Santa Maria	1,000
Standard Oil Co., Newhall	450
American Gasoline Co., Santa Maria (two plants)	1,400
Purity Gasoline Co., Santa Maria (two plants)	1,700
Pinal Dome, Santa Maria (two plants)	3,500
Frank Hall, Santa Maria	500
Olinda Gasoline Co., Olinda	1,000
Hurley-Smith-Callins Co., Oleo	2,500
A. F. Gilmore, Salt Lake	450
Total	16,950

When the new plant now being constructed for the Union Oil Company begins operations 8000 gallons daily will be added to the total.

OPPOSITION to the application of Mr. E. G. Ryan for water rights on Rush creek, Mono county, California, developed at the preliminary hearing before the State Water Commission. Mr. E. F. Scattergood, electrical engineer for the Los Angeles aqueduct, objected to the issuance of the permit on the ground that the city might require the water as a source of future power supply. As Los Angeles now has over 100,000 horse-power undeveloped, it is difficult to see the merit in its contention, while a transmission line 350 miles long presents engineering difficulties that have not yet been solved.

STRIKING evidence of the extent to which California oil has displaced coal is shown by Mr. Edward W. Parker of the United States Geological Survey in a report recently made public. He says: "On account of the large production of petroleum in California and its use for fuel, coal mining has practically ceased in that state, the production in the last two years being only 10,747 tons in 1911 and 10,978 tons in 1912. The production of petroleum in California in 1912 was 86,450,767 barrels, of which not less than 50,000,000 barrels was used directly for fuel. Large quantities of oil are also used in place of coal for gas making, and on the estimate that 3½ barrels of petroleum is equivalent to 1 ton of ordinary bituminous coal, it is probable that 1,400,000 to 1,500,000 tons of coal would be required to perform in California the service now rendered by petroleum in the production of heat, light, and power. California oil is the principal fuel for locomotives as far north as Washington and across the Sierra and the Cascade range, its freedom from sparks serving as a great protection against forest fires, as compared with coal or wood fuel. It is used almost exclusively on inland and coastwise steamers and to an increasing extent by the trans-Pacific steamers. It has even displaced coal on Puget sound, many of the steamers of the Canadian Pacific fleet plying between Vancouver, Victoria, and other points having been equipped for oil burning. There is still, however, some demand for coal in California, particularly for domestic use and for bunker trade at San Francisco, but it is almost exclusively supplied by coals from other states and from abroad. There are, however, in California a number of small widely separated coal-fields, chief among which are the Mount Diablo fields of Contra Costa county, the Corral Hollow field of Alameda

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county, the Priest Valley and Trafton fields of San Benito county, and the Stone Canyon field of Monterey county. The first two, which are on the eastern border of San Francisco bay and consequently in the west-central part of the state, produce black lignite or sub-bituminous coal. The coals in Monterey county are of the same geologic age as those farther north, but they have been altered into true bituminous coals. The alteration in the San Benito county areas has not progressed so far as in Monterey county, but the coals closely approach the bituminous grade. None of them possesses coking qualities."

The Welfare of the Farmer

If you want a thing done, do it yourself. This statement may not possess the merit of originality, but we in the West seem to have lost sight of its application in developing our uncultivated land. Mr. John H. Lewis, state engineer for Oregon, in an address delivered before the Columbia-Snake River Waterways Association and published in this issue, has struck a keynote in the enunciation of this principle. "Why is it necessary to await appropriations by Congress when we have an enormous reservoir of credit in the $2,000,000,000 of assessed valuation of these three states," and the answer is, why? There seems to be a disposition on the part of many people to magnify the importance of urban growth and to consider that large cities are an unfailing indication of rising wealth and prosperity. In many instances annexation schemes are promulgated whereby small towns and villages are included in city limits within radii of 20 and even 30 miles and leaving large areas unoccupied. As a matter of fact, the city is a consequence of the country, and its prosperity and healthy growth is no more than a measure of the degree of success attained in the development of the interior lands. That this fact is recognized by far-sighted capitalists is shown by the remarkable development that is under way in the vast irrigation and reclamation projects in the West, and especially in the Pacific Coast states. In fact, it is a question whether there are not more irrigation projects than are justified by present conditions. There is no doubt that while many of these projects are sound, ably administered, and well engineered, there are others that rely more upon the claque of the advertising expert and the specious promises contained in gaudily illustrated circulars than on the intrinsic value of the land and the truth regarding its economic possibilities. The promoter is the chief offender and does incalculable damage to the whole community. Glittering predictions are made as to the marvels that may be accomplished with 10-acre farms. The farmer is depicted riding majestically to town in his automobile to deposit his season's profits with his smiling and affable banker. These small farms are sold on the installment plan at enormously high prices, often from five to ten times in excess of their cost to the promoter, and the victim is assured that after the first few payments are made, the earnings from the farm itself will provide for the future. "Time is of the very essence of this contract" is apt to appear in one form or another in the conditional bill of sale, and the embryo farmer will soon learn to his cost that a default in any payment will, under the contract, cause his farm to revert to the company from which the property was purchased. He will then have lost his savings, and have to face the world anew. It would be interesting if one could obtain statistics showing the percentage of resales of land for promotions of this character.

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but data of this kind are one of the secrets of the trade and are jealously guarded from the public. How these occurrences may be prevented and how the uninformed investor may be protected is a large problem. Under present conditions the way of the promoter is comparatively easy. He obtains long time options on arid or semi-arid land, favorably situated as regards water supply, at prices from $20 to $50 per acre. His engineers build reservoirs, ditches, pumping plants, and pipe lines; the land is subdivided and the advertising campaign is on. The land is placed on sale at $150 to $350 per acre, and it is a race against time to see if enough land can be sold and first installments paid to provide funds for meeting the options when they come due. We hold no brief for government ownership, and believe that when the interests of the people may be properly safeguarded the country may better be developed by private enterprises. Mr. Lewis, however, has offered some suggestions with regard to the welfare of the farmer and the development of the cultivable area in Oregon, Washington, and Idaho that, carried into effect, would do away to a large extent with evils such as we have described and promote the development of this region. Transportation is admittedly the greatest factor in the development of a community, and cheap power is a close second. The comprehensive plan outlined for the canalization of the Columbia and Snake rivers would be of incalculable benefit to the tributary territory. As Mr. Lewis points out, one dollar will pay for carrying one ton 15 miles on an efficient wagon road, 150 to 300 miles on an efficient railroad, 1500 miles on an inland deep waterway, and 2000 to 3000 miles on the ocean. Many farmers in the district mentioned have this year sold alfalfa hay below cost. Under the lower cost of transportation possible with a system of inland waterways the prices obtained would have returned a good profit. Instead of discouragement and in many cases abandonment of farms, increased settlement would have resulted to the benefit of the entire state. Such a project is too vast to be undertaken by private enterprise, and only by coöperation between state and nation could it be made possible. The use of the national and the state credit would eliminate practically all financial risk. This, together with the avoidance of promotion expense, would result in low costs, and by distributing the burden over a long term of years, the individual share would be comparatively slight. Some such idea must ultimately be carried out. The farmer should be aided to whatever extent possible rather than exploited by the promoter with no motive other than private gain. It is the fashion to ask the national government to carry all of the burdens in projects of this kind, but it is commencing to be recognized that a fair division of cost as well as benefits is the only basis upon which national aid may be expected. Until some coöperative plan is devised, the menace of floods on the Sacramento and San Joaquin rivers will be of yearly recurrence. The inhabitants of the cities should not be deluded into the belief that remedial measures for the welfare of the farm do not affect them. On the contrary, the welfare of the farmer and the success of his farm vitally affect the entire people, and the cities should coöperate with and lend their best efforts to further the success of every legitimate enterprise for the development of the interior lands.

The greater proportion of immigrants expected when the Panama canal opens will settle on farm lands. To reap full benefit from this new population it should be protected, not exploited.

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REVIEW OF THE MONTH

AFFAIRS have continued to mark time during the month. Money is still tight, the currency legislation now pending before Congress apparently being the astringent. At the recent convention of American bankers, almost unanimous disapproval was expressed of the proposed currency law. The administration is apparently determined to adhere to its party pledges, and there seems little reason for doubt that government regulation will soon be extended to the money market to the same extent as it has to other fields of commercial life. There is every reason to believe that the pending bill with some minor modifications will become a law before January 1, and that 1914 will show an activity in development enterprises that will well repay for the dull times of the last six months.

STREET car service has been defined in the arbitration proceedings recently conducted to settle a dispute between the Southern Pacific company and its employees in the Alameda county suburban electric train service. The installation of car service between Oakland and Alameda brought the matter to an issue between the railroad and the Brotherhood of Railway Trainmen, who contended that their wage scale should obtain for this work. The railroad took the position, however, that this was street car service in the ordinary acceptance of the term and should command the same wage scale as is ordinarily applied. After an extended series of hearings, the arbitration committee rendered a decision in favor of the railroad's contention, fixing the status of the operators of the Oakland-Alameda line as engaged in street car service and entitled to the usual compensation for this class of work. This means that motormen will receive $2 per day and conductors $35 per month less than the rate paid operators on the company's suburban electric trains, who are paid the same rates as for steam line service. This is one of the first decisions rendered through the operation of the Newlands arbitration act, and establishes a precedent that will undoubtedly have a far reaching effect upon railroad wage disputes of similar character. As the cause of the dispute would, under former conditions, have undoubtedly caused a strike, the public have reason to be thankful for the improvement over the old method of settling labor wage disputes. We hope that the operation of the Newlands act may be equally effective in other branches of industry.

BY far the most important event of the month took place on October 10 when the President at 2 p.m., Pacific time, gave the signal that exploded a charge of dynamite and destroyed the Gamboa dike, the last great physical obstruction to the opening of water communication in the Panama canal. The removal of the dike material and the earth slides at Cucaracha and Gold Hill must be accomplished before the canal can actually be open to traffic. Fourteen units of the Atlantic dredge fleet passed through the Gatun locks and are busily engaged in the removal of the débris. This marks the beginning of the end, and the master engineering feat of the age will soon be completed, a monument to the skill and ability of the American people.

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SIGNING of the Underwood-Simmons tariff bill by the President on October 5, marks the accomplishment of the downward revision of the tariff for which the country has been waiting for many years. Merchandise to the value of many millions of dollars has been released from warehouses where it has been held in bond. While advertisements of reduced prices due to the new tariff are beginning to make their appearance, it is not to be expected that the price reductions will be so marked as to have an immediate effect upon the individual, however, and the changes will take place gradually as business becomes adjusted to meet the new conditions. The use of two gold pens by the President, in the presence of Mr. Bryan for signing the document recalls the presidential candidacies of the latter at which the ratio was 16 to 1 rather than 2 to 1.

ACTIVITY in the oil situation continues to centre upon the progress of the Royal-Dutch-Shell interests. It has been reported that their latest acquisition is the property of the Turner and W. K. oil companies in the Coalinga fields. For the W. K. it is stated that $1,750,000 was paid, a rate of $3.50 per share, and for the Turner $1,500,000, a rate of $3 per share. The Fleishhacker interests, well known in Pacific Coast power and banking circles, are the largest stockholders in both oil companies, and will obtain a substantial profit on their holdings. The property in question comprises a whole section in the Coalinga field at the east side. Development was commenced in 1905 and for some three years the results obtained were not encouraging. The patience of the operators was finally rewarded and a well was brought in at a depth of 3000 feet that yielded 2500 barrels per day. From that time on operations have been successful. When the titles have been finally approved and the purchase price paid over, the Shell interests will have a total output in the Coalinga field of 23,000 barrels per day, of which some 15,000 barrels will be produced by the California Oilfields, Ltd., whose property they acquired some time ago.

GOSSIP is still busy over rumors that the Shells will also acquire the property of the General Petroleum Company, United Petroleum Company, Mays Oil Company, and others. While there seems reason to believe that negotiations are under way for the purchase of the two first mentioned, it is not unlikely that the rumors of other purchases emanate from stock market interests for reasons that are obvious. Should the property of the General Petroleum Company be acquired, that, together with the purchases that have already been made, will keep the Royal-Dutch-Shell Company busy for some time to come. It is stated that the Shell Transport & Trading Company is about to make a further issue of ordinary shares in order to provide capital for extending its operations. Operators on the London stock market do not take kindly to the Shell policy of making stock offerings under terms that offer little or no bonus to existing stock holders, as it offers them no opportunity for resale at a high profit on the stock exchange. The management seems bent upon securing the greatest possible benefit to the Company as a whole, rather than indulge in the melon-cutting propensities of their American cousins, a course which in these days of stock watering is both unique and commendable.

THOSE who profess to see in recent legislation for the regulation of water power permits a death blow to future development work are shown to

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be dismal failures as prophets. According to the United States Forest Service, a permit has just been granted to the Southern California Edison Company for the development of additional electric power on the Kern national forest to supply Los Angeles, Pasadena, and neighboring towns. This company operates seven hydro-electric plants, one of which is on the Kern and five others on the Angeles national forest. The six plants on the national forests are capable of developing 37,000 horse-power, although there is not sufficient power in the streams to develop such an amount of power continuously. The company has installed, therefore, a number of auxiliary steam plants, which have a total capacity of about 54,000 horse-power. While it might be supposed that, with such an amount of power at the company's command, there would be little need of an additional supply, especially with other companies operating the same territory, the Edison company was convinced several years ago that it would eventually need more power in order to supply its market. The four water-power sites which seemed to be the most valuable for development are on the Kern forest, so application for power permit was made through the forest service in order that the company might develop these sites. It was the permit for this development which was granted by the Secretary of Agriculture.

THE four projects mentioned in the permit are designated by the Company as Kern River plants 2, 3, 4, and 5. It is expected that plant No. 3 will be the first to be put into operation, with 4, 5, and 2 following in the order given as the demands of the market increase. It is stated by the company that expensive dams will not be needed, but that the construction of some of the conduits will be difficult and will require a considerable amount of time. Because of this, and also because of the large investment required and the large amount of power that is involved in the development, the Department of Agriculture allows a period of almost 12 years before the plants will have to be in complete operation. According to the estimates of the government's engineers, the four new projects of the company will be able to supply almost 33,000 horse-power, except for a few days in a period of five years. Through the use of its steam auxiliary plants, however, the company will be able to obtain considerably more than that amount, and it is planned to install machinery which will have a total capacity of more than 80,000 horse-power. This will be transmitted at high tension by means of poles and steel towers over a maximum distance of about 155 miles from the plants to the city of Los Angeles.

A WATER POWER permit has just been granted by the Secretary of Agriculture to the Truckee River General Electric Company, a California corporation, under which this company will develop power on the Eldorado national forest, to serve various California towns and cities. In developing power the company states that it expects to construct seven reservoirs, five for water storage and two for equalizing the flow. Two of the storage reservoirs are on upper Rubicon river. By the use of a tunnel approximately a mile and a half long the flow of the upper Rubicon river and the waters stored in these two reservoirs will be brought into the Gerle creek drainage, where the waters will be further stored. From this storage the water will be conveyed by ditches and natural streambeds to Pilot creek, upon which the two power plants mentioned in the permit are to be located.

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The water will finally be discharged into the Rubicon river. At each of the two plants there will be a head of approximately 1300 feet. The company expects to make an initial installation which will develop about 16,000 horsepower, which will probably be doubled as the market for the product increases.

ACCORDING to Mr. F. C. Hermann, chief engineer for the Spring Valley Water Company, construction work on the Calaveras dam is well under way. This is an earth-fill dam with a clay core similar to that at San Andreas and of the same type of construction as used for the famous Gatun dam at Panama. The material will be sluiced into place, the finer particles of clay lodging at the centre while the pebbles and coarse material will fall on either side. The total quantity of material to be handled aggregates 3,250,000 cubic yards, the width at the base will be 1300 feet, the length at the crest 1350 feet, and the full height is planned as 220 feet. It is expected that by December 1914 the dam will have been completed to a height of 120 feet, which will enable it to impound 8,000,000,000 gallons of water, or sufficient to add 25,000,000 gallons daily to San Francisco's domestic water supply. It will take until the end of 1916 to complete the dam to its full height, which will provide a reservoir of 55,000,000,000 gallons capacity. The work thus far done consists in the construction of a reinforced concrete conduit 20 feet in diameter which will be utilized at present for carrying off the flood waters during construction, and afterward as an outlet for the reservoir.

JAPAN'S rising importance as a producer of petroleum is indicated in a report recently issued by the Austro-Hungarian consulate in Yokohama. "The average consumption of petroleum in Japan," states the report, "amounts to about 10,000,000 cases per year, of which 5,500,000 cases are imported. The home production has increased considerably in the last few years, this being mainly due to the installation of American drilling machinery on the Echigo oilfields. According to the latest statistics, the yield of oil in that district was last year, 1,420,000 kokus, or about 56,374,000 gallons. The most important wells are in the vicinity of Kambura, Nishiyama, Higayama, Nashima, Kabiki, and Uonoma. The quantity of oil raised by machinery is about 400 kokus per day (15,880 gallons), valued at 4000 yen. The quantity which can be obtained by hand is insignificant. Although the consumption of oil for lighting purposes is on the decrease, owing to the adoption of electric lighting throughout the country, the consumption of oil for motor-boats and motor vehicles generally is growing. All the petroleum imported was either from the United States or the Dutch Indies, the figures for 1910, 1911, and 1912 being:

	Quantity in gallons.	Value in yen.
From the Dutch Indies—		
1910	21,826,775	4,348,685
1911	20,662,981	4,054,567
1912	15,909,788	3,361,445
From the United States—		
1910	47,141,356	9,954,605
1911	43,004,290	9,010,813
1912	40,901,358	9,071,735

"Other mineral oils of a value of 1,276,805 yen were imported, these coming almost exclusively from America. The imports of petrol were as follows:

	Quantity in gallons.	Value in yen.
1910	664,506	163,378
1911	1,595,591	326,704
1912	2,245,027	655,962

"During the same period the imports of paraffin rose to 58,750 yen. The total value was 1,921,000 yen."

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Condit Plant of Northwestern Electric Company*

THE White Salmon river rises on Mt. Adams and flows south through the state of Washington, entering the Columbia at a point about 70 miles east of Portland, Oregon. The site of the development, named the Condit Plant after B. C. Condit of the Northwestern Electric Co., is some 3 miles up the river and is reached from Underwood on the Spokane, Portland & Seattle railway, known as the 'North Bank' railroad.

Work began in May 1912, with the construction of a road from Underwood up the west side of the White Salmon to a point just below the location selected for the power-house. Crossing the gorge at this point, the road was continued around the site of the power-house and up the east bank to the dam site and the job headquarters.

The development is 20,000 hp. and required about ten months to build, the first unit being turned over March 21, 1913. It is interesting as a type rather than for exceptional features, though one feature, the flow line, is said to be unequalled among conduits of its kind.

Cofferdams diverted the river into a flume which led through two tunnels to a 'frog' below the dam, one branch discharging into the river and the other continuing through tunnel No. 3 to a temporary power-plant. The power-flume was provided with a spillway and the flow to the plant was maintained at an elevation of 6 ft. by Tainter gates in both diversion and power-flumes. These gates were raised or lowered according to the flow in the flume. Every part of the diversion scheme was made very strong. The sills of the flume were tamped in place with crushed rock and the sides were box shaped so that they could be ballasted. The main cofferdam was boarded over to form a spillway.

Two 60-in. sluice gates were left in the dam, partly to take care of operating necessity for lowering the pool and partly as a construction expedient. The flume was built to carry 1500 second-feet and, at the tunnel which pierces the rock underneath the dam, was provided with a gate which might be closed at any time if the flow became so great as to endanger the temporary power-plant below. The diversion scheme was fully tested by floods. While construction work was at its height and the ground was covered with snow, a downpour of rain caused the river to rise rapidly to about 3500 second-feet, submerging the flume for 48 hours under 4 ft. of water. The water poured over the cofferdam and pooled behind the dam, discharging through the sluice gates and flowing over the sides of the flume where the water had reached its maximum velocity. It was not necessary, however, to close the temporary gate. With a change of weather the river dropped, and with it the pool above the dam, and conditions became normal. The ballasting of the flume thus took care of the situation, as planned.

The temporary power-plant was

*From data supplied by Stone & Webster, Engineering Corporation, Boston, Mass.

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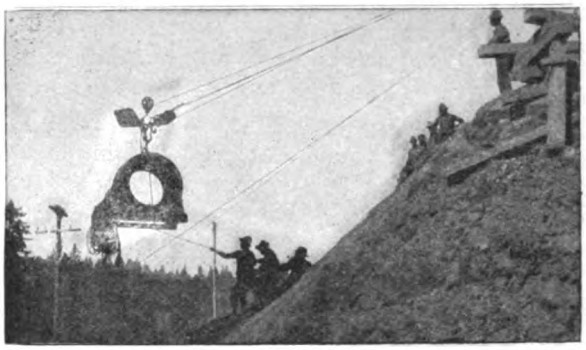
equipped with a 54-in. S. Morgan Smith wheel which developed 300 hp. at 13-ft. head. There were two 150-kw. machines generating current at 440 volts. This was the voltage at the motors in the various parts of the work and also the voltage for transmitting the current to the dam. For transmission to the work at the permanent power-house a mile down the river, the current was stepped up to 6600 volts.



LOWERING GENERATOR STATOR TO TEMPORARY POWER-PLANT.

The crusher and concrete plant was placed on the west side of the river directly below the quarry which was 400 ft. above the river. The location of the quarry and the steep slope down to the dam-site permitted a design in which the rock was handled by gravity alone. The quarry rock is shattered basalt. It is made up of the lava flow of past ages from Mt. Adams, 35 miles above. It is good concrete material, and from it was manufactured all the sand as well as the rock.

Both air-drill and hand-drill gangs were worked in the quarry. The excavated rock was dragged by a Bagley scraper to the crusher chute, after which it was passed through the various operations entirely by gravity. Below the crusher, revolving screens separated the sand and small rock from the large rock, sending it directly to the sand and rock-bins, while a portion of the rock went to the hammer-mill for further reduction.

UPPER END OF CRUSHER PLANT.

Two concrete mixers were installed about 150 ft. above the crest of the dam,

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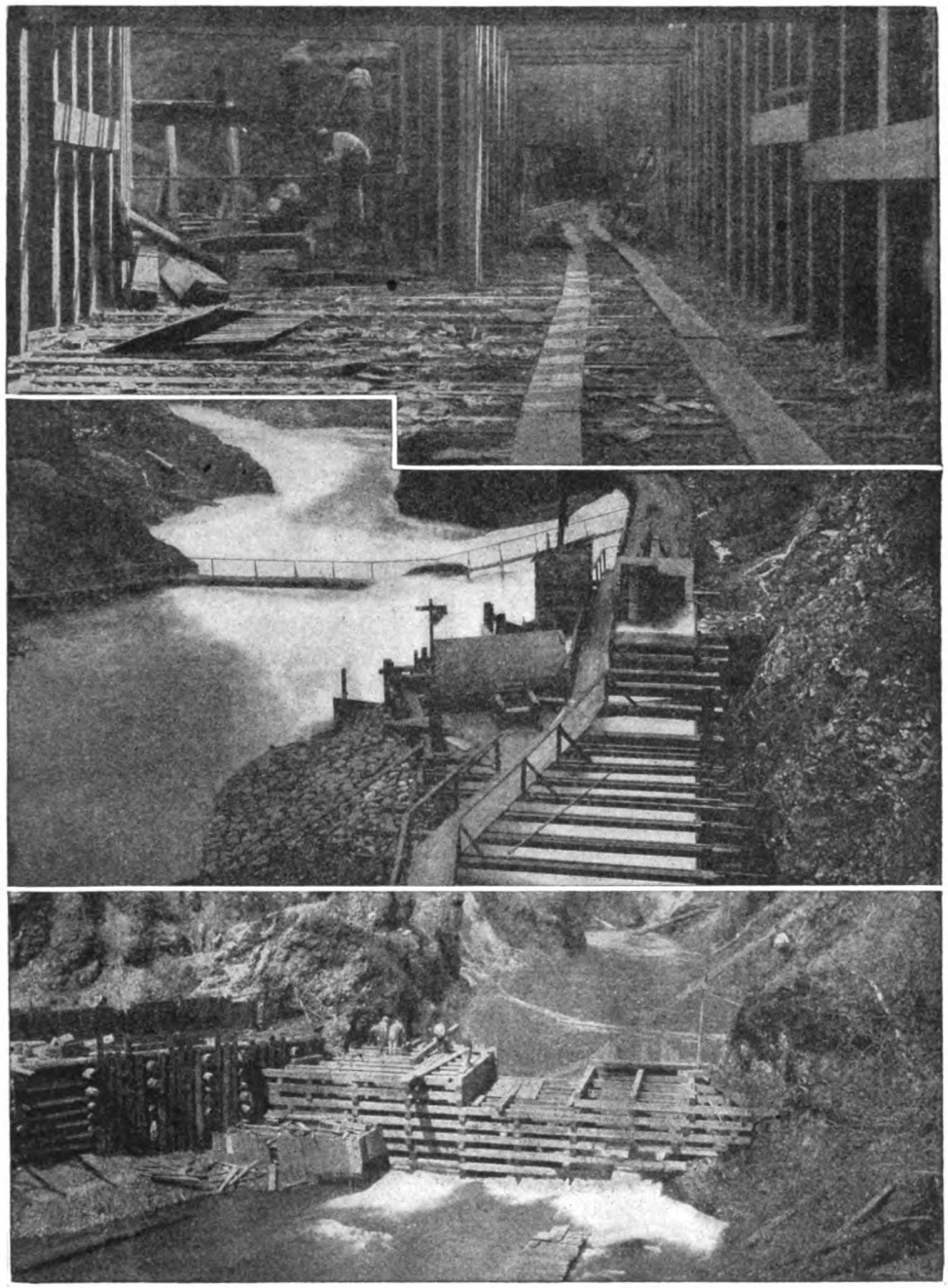

CONSTRUCTING FROG IN THE FLUME BELOW THE DAM.
COMPLETED FROG WITH TAINTER GATES IN OPERATION.
UPSTREAM FROM DAMSITE, SHOWING DIVERSION COFFER-DAMS UNDER CONSTRUCTION.

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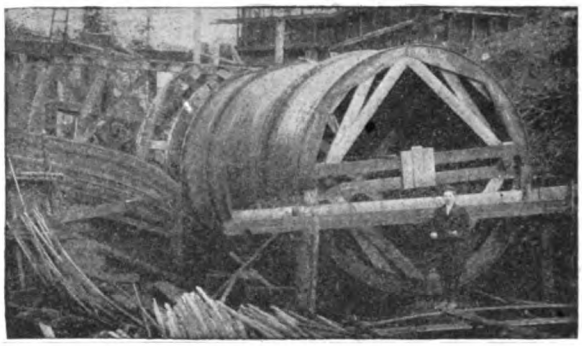
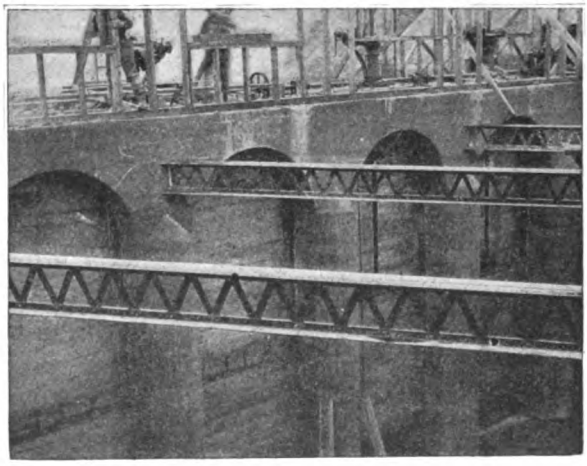
from which height 80% of the concrete was chuted into place. The plant demonstrated a continuous capacity of 10,000 yd. per month with two mixers working about ten hours per day. The record run for a day of ten hours was 720 yards.

The dam contains 30,000 cu. yd. of concrete. It is 125 ft. at its greatest height and the entire structure, including headworks, is 471 ft. in length with a spillway section of 232 ft. The rollway is 88 ft. thick at the base. The seal between the concrete and the bedrock is unusually perfect. The bottom is very rough, low on the upstream side, clean and well broken, with the concrete keying into pot-holes everywhere.

About 80% of the concrete was deposited by gravity, being chuted from the crusher plant to a distance of about 285 ft. from the west abutment. Of the remaining 20%, part was brought from the crusher plant by cableway to a hopper over the east abutment and there sluiced into place, and part was chuted into a hopper at the middle of the dam and then placed by derrick.



STEEL NIPPLE JOINING FLOW LINE WITH HEADWORKS.



HEAD GATES.

The headworks on the eastern abutment consists of five gates with 8 by 9-

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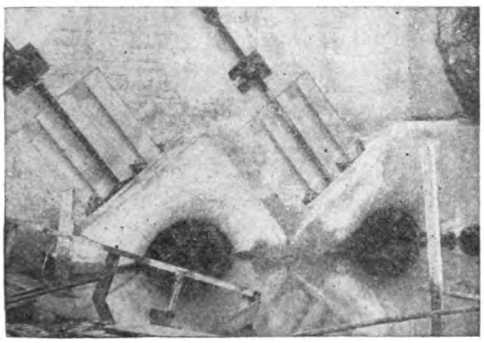
ft. openings converging into the flow-line. The gates are of wood with brass bearing plates and are raised and lowered by valve stands in the gate-house,

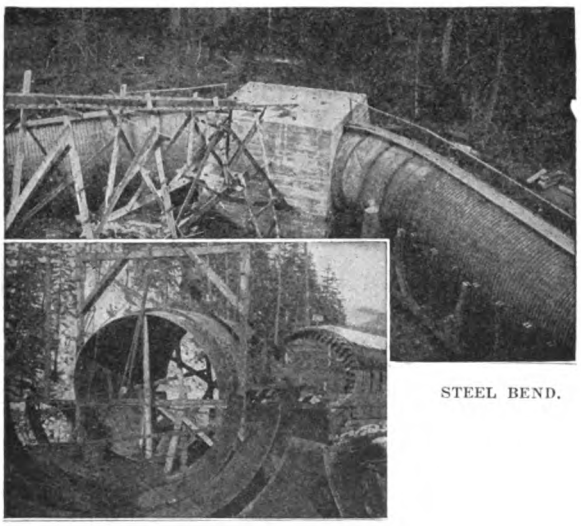


SLUICE GATES.

so connected by a drive-shaft that they can be operated either by machinery or by hand.

below the crest of the dam, are two 60-in. sluice gates used to carry away deposits of silt which may collect in the bed of the river. The sluice gates are opened and shut by gate stems which run diagonally along the back face of the dam to valve stands on top of the headworks.

The flashboard construction is particularly well adapted to the flow conditions of this river, which, like other Washington streams, is subject to short periods of comparatively high water throughout the year. In order to save as much of the plank as possible during these high-water periods, the flashboard pins are so designed that they will fail in sections, the middle section first, the section on the west side next, and the section on the east side last. The dam is designed on a



STEEL BEND.

ERECTING STEEL PLATE IN BEND.

The headworks are provided with ample screen surfaces and a trash sluiceway through which débris gathering in front of the screens is carried over the dam; and an opening is provided on the western abutment for log sluicing. In the gorge, about 100 ft. basis of the maximum flood being 20,000 second-feet, which would take out all of the flashboards and leave a free crest.

Wood stave pipe, 13 ft. 6 in. diam., is used for the flow-line. It is one mile in length, extending along the gorge

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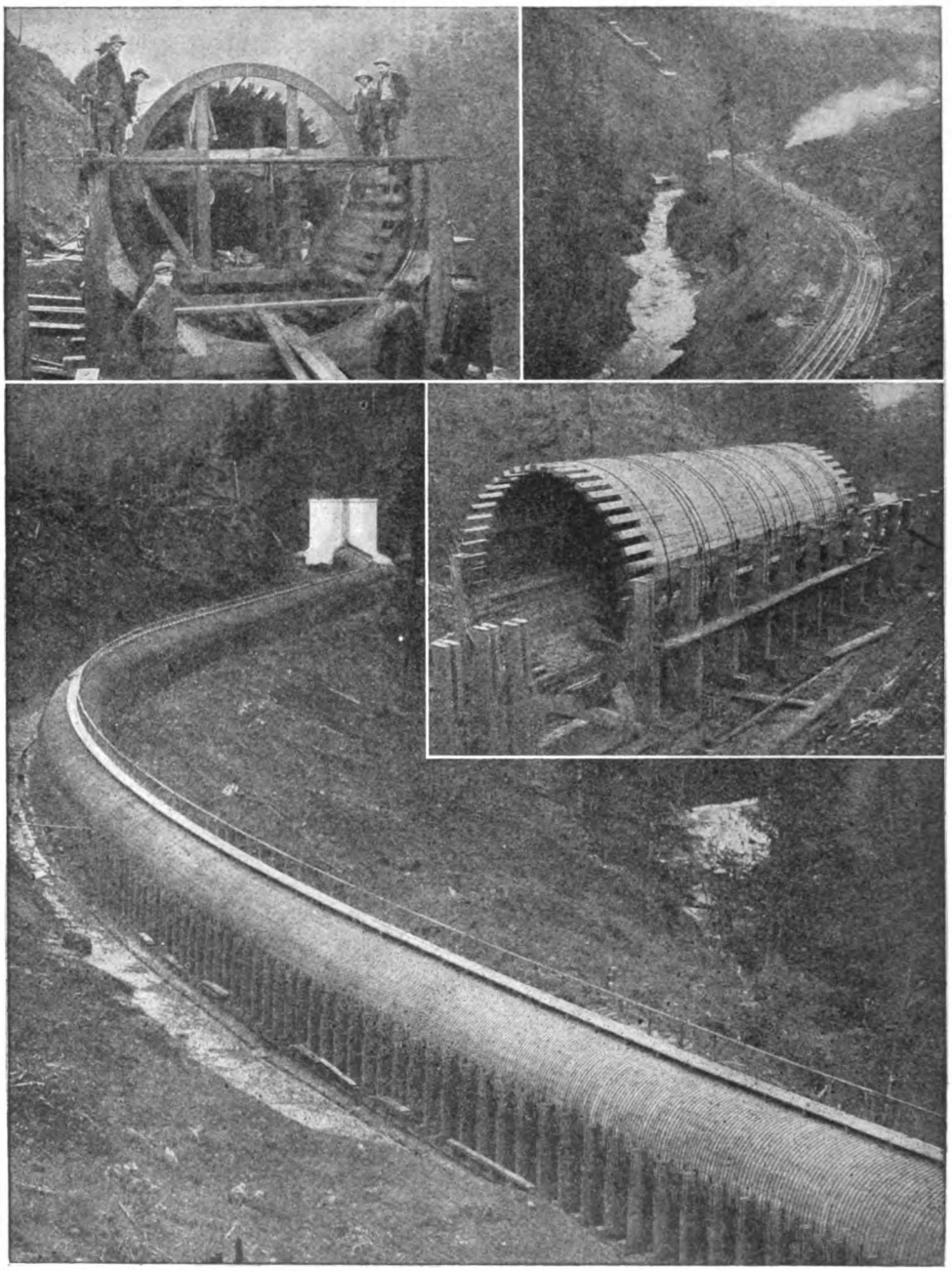

FLOW LINE FEATURES: UPPER LEFT, PLACING FLOW LINE STAVES. UPPER RIGHT, PIPE-LINE GRADE, SHOWING THE HEAVY LONGITUDINAL MUD-SILLS. CENTRE, SECTION OF COMPLETED PIPE SHOWING CRADLES AND SUPPORTING ARMS. LOWER, FLOW LINE AND FORE BAY.

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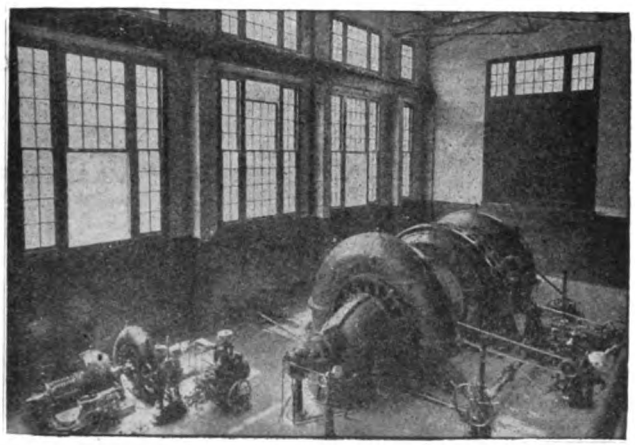
from the headworks on the eastern abutment of the dam to the forebay near the power-house. Over 1,600,000 ft. of timber was used. In the pipe proper there is nearly 1,000,000 ft., in the cradles 476,000 ft., and in the sleepers or mud-sills 210,000 ft. The pipe has 94 staves in its circumference. The total length of staves is nearly 90 miles. It is supported by 1108 cradles, resting on seven heavy mud-sills running the full length of the line.

The stave stock is what is known in the lumber world at No. 2 Douglas, or Washington fir, and is nearly all absolutely clear. It is kiln dried, and planed with beveled edges so that when fitted together the pipe forms a true circle. It comes from a part of northwestern Washington which is fast being cut, and the timber is so good that a great amount of waste does not result, but to get this million feet it is probable that at least 3,000,000 ft. of standing timber was cut. In other parts of the state the ratio of stave stock to the cut is higher, in some cases running as high as one to six or seven. This lumber came from half a dozen mills, each being able to supply only a small amount of the grade required.

While the theory of laying and fitting stave pipe is simple, there is a great knack in fast and workmanlike placing of staves which comes only with experience. One gang erected 180 lineal feet in one day, and on many days 100 ft. was erected, while the average in all kinds of weather was not less than 80 feet.

The weight of water in the pipe when full is approximately 4 tons per foot, static load, which is more than weight per foot of length of the heaviest locomotive. Every means was taken, therefore, to make the foundations perfect. The roadbed is all on solid ground, the total excavation being 130,000 yards.



MAIN AND EXCITER UNITS.

The forebay is a concrete tank 40 ft. diam., the top being 10 ft. above the crest of the dam. The sub-structure is built entirely in cut and of such a shape that the water passes from the flow-line to two 9-ft. wood stave pressure pipes without change of velocity. Drainage is provided for the sub-structure and an overflow takes care of excess water during changes in load at the power-house greater than the capacity of the relief valves.

From the forebay the pressure pipes drop 160 ft. to the power-house. They

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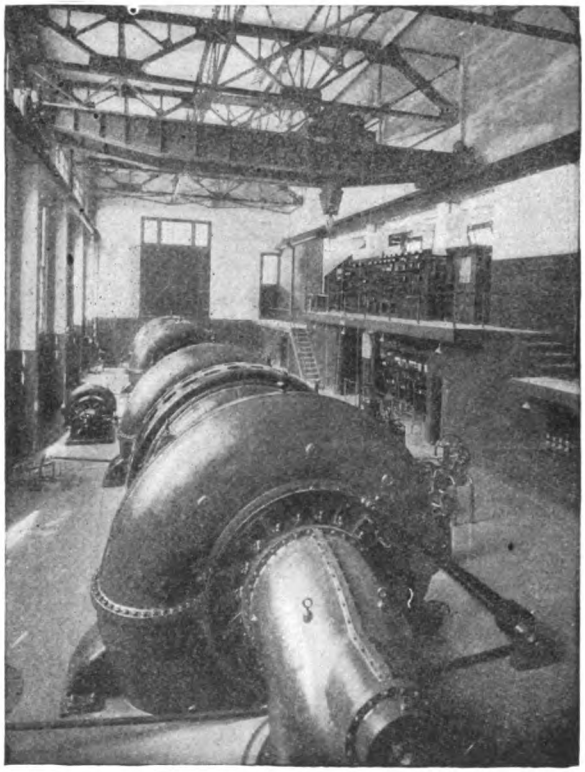
are 650 ft. in length, and of wood stave construction to a point near the power-house where they join steel sections. Where they join, the wood staves are lapped 30 in. on the steel, and the bands are placed as close as possible. The inside of the steel pipe is the same diameter as the inside of the wood pipe. This produces a slight flare in the staves, which allows the bands to be cinched, making the joints absolutely tight.



GENERATOR ROOM.

Each unit consists of a pair of turbines of a combined capacity of 10,000 hp. with a generator of 6000 kw. capacity mounted on the shaft between them. Each penstock divides at the power-house and connects with the two parts of a unit.

The material excavated for the substructure was hoisted by derricks to an incline tramway which deposited it on the hill above the power-house. Other derricks reclaimed it and dumped it into the crusher, where it was broken for concrete aggregate. The rock and sand were chuted down the hill to the mixer, which chuted the concrete into an elevator hopper. The elevator raised it to various heights and chuted it into place to form the power-house structure.

The power-house is constructed in two general sections running the full length. Overlooking the generator room which faces the river is the switchboard gallery flanked on either side by the transformer cells. The high-tension switches and bus-bars are on the top floor.

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Materials and supplies were hauled from Underwood, and in the early part of the work teams and motor trucks were used, each motor being equivalent to twelve teams. When the weather conditions prevented the use of trucks, the force averaged eight teams. Each team made two trips per day. The heaviest single loads were the lower halves of the stators of the generators, which weighed 17 tons each. Donkey engines hauled the wagons up the grade out of Underwood, and the rest of the way 16-horse teams were used.

When the pipe sections for the lower part of the pressure lines arrived in Underwood, a heavy fall of snow threatened to delay getting them to the job, but sledges were improvised and time was saved by hauling over the snow.

The laboring force varied according to the requirements of the work. For the greater part of the time the average was about 900 men. Toward the end of the job this number was increased to about 1500.

Investigation of the Upper Atmosphere*

By J. MASCART

ON December 17, 1912, a balloon liberated from the aerological observatory in Pavia reached an altitude of 37,700 metres (123,600 ft.; 23.4 miles). This is the loftiest exploration which up to the present time has been made instrumentally in our atmosphere, and the remarkable result merits general attention.

The balloon used in this flight was made of para-gum, by the Continental Caoutchouc & Gutta-Percha Company of Hanover, was inflated with hydrogen, and was provided with a parachute; its diameter, 1.9 m., the largest used up to the present time for this kind of exploration, was made necessary by the special apparatus that the balloon was to carry. The flight was entirely normal and without any untoward circumstances; the balloon returned to the earth at a distance of 39 km. (24¼ miles) from the observatory.

The following are some of the characteristics of this achievement.

The minimum atmospheric pressure observed was 2 mm.; the minimum temperature registered was –56.9°C. at the altitude of 19,730 m. (64,800 ft.). The stratosphere was encountered at an altitude of 12,385 m. (40,600 ft.), with a temperature of –55.5°C.; the temperature in it remained constant for some time, then increased and later diminished, again increased and reached finally –51.6°C. at the maximum altitude registered.

But if the remarkable results obtained by this balloon sent up by Professor Gamba are worthy of special note, those obtained by the early pioneers in this field of investigation must not be forgotten. What really are the explanations of the unusual phenomena observed at the higher altitudes? What is the stratosphere? Who was the first to obtain exact information concern-

*Original in *La Nature;* translated from the Esperanto in Scienca Gazeto by A. H. Babcock.

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ing the layers of heat inversion, their variations according to the seasons, and their influence upon general meteorology? The answers to these questions are given below in the form of a résumé of the preceding work.

We call the atmosphere the gaseous envelope of the earth which is necessary to life as we know it. As a matter of fact, to the gases contained in this atmosphere are due the different observed phenomena; for example, combustion, breathing, etc. Upon the surface and at points very close to the surface of the earth, the constituents of the atmospheric air are known with great precision; the gas which we breathe consists of a mixture of 78 volumes of nitrogen and 21 of oxygen; the 100th part remaining, which soon will be known with great precision, contains carbonic acid, aqueous vapors, small proportions of argon, and other rare gases such as helium, neon, etc. It should be noted that the aqueous vapors and carbonic acid occur in different proportions in different specimens of air that have been analyzed. The average weight of the atmosphere at sea-level corresponds to the weight of a column of mercury 760 mm. high.

When we leave the lower altitudes, either by climbing a high mountain, or by balloon, we observe that the density of the air decreases, that combustion is made with more difficulty, that breathing becomes more laborious; all these phenomena indicate to us that the thickness of the gaseous envelope is not without its limits. Actually, this layer is carried around with the earth in its rotation upon its axis, and from this it follows that in the higher regions the gaseous molecules will be greatly decreased for the reason that two forces act upon them—gravity, which tends to bring them together at the centre of the earth, and the centrifugal force, which, affecting them inversely, tends to drive them away from the earth.

Through some limiting surface, one of these forces becomes predominant; if the centrifugal force is in excess, the particles are no longer retained by the earth, are driven away from its influence, and consequently cease to be a part of our atmosphere. Calculation shows that this surface lies about 5 or 6 radii of the earth distant from its surface. This corresponds approximately to one-tenth of the distance from the earth to the moon. Its theoretical limit is 34,000 km. (21,200 miles).

Shooting stars make possible exact measurements of the thickness of our atmosphere. Aerolites entering it with great velocity meet the gaseous atmospheric particles, become heated by friction up to luminosity, and therefore become visible to an observer situated upon the surface of the earth. Simultaneous observations made at different localities enable us to calculate by triangulation the height at which this atmosphere was met by the aerolite. The greatest altitudes obtained by this process are in the neighborhood of 200 to 300 km. (125 to 187 miles).

It is not necessary to go further into the other methods by which the thickness of the aerial layer can be calculated. We have now sufficient of an idea concerning its order of magnitude; but in what manner is this gaseous mass divided? It will be readily understood that concerning this our knowledge is limited on account of the methods necessarily employed; because up to the last few years the only means we have possessed has been the ordinary balloon; but for the last fifteen years kites and principally free balloons have given us the ability to explore the atmosphere to a much greater extent.

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From the physical viewpoint, the lower part of the atmosphere may be divided into three parts.

The first reaches from the earth's surface up to approximately 3000 m.; in this zone there exists almost the entire quantity of water vapor and dust; here the phenomena depend upon the inequalities of the earth's surface, because these cause and here originate nearly all of the greater atmospheric disturbances. The temperature here decreases very irregularly and often shows the phenomenon of inversion; that is to say, that instead of decreasing as the altitude increases, it becomes warmer in certain layers, the thickness of which can reach 1500 and 2000 m. This atmospheric layer has been very thoroughly studied by means of observers in balloons, by captive balloons, and principally by kites.

The second layer lies from 3000 up to 10,000 m. In it are found only a few clouds, and the temperature uniformly diminishes; at 10,000 m. are observed the lowest temperatures, with some very attenuated clouds which consist of ice particles; also, at about this altitude man is obliged to halt; on July 31, 1901, Berson reached a height of 10,800 m. (35,500 feet).

By kites and by observers in balloons we have been able to explore the lower levels of the second layer to between 5000 and 6000 m. Contained in these two first layers is that which Leon Teisserenc de Bort has called the troposphere, because of his theory that in this region occur the vertical movements of the air.

The remainder of the atmosphere belongs to the third zone, which is known as the stratosphere, for the reason that in it the vertical movements of the air do not exist. To explore this layer thoroughly it is necessary to use the free balloons; that is to say, small balloons made of paper or caoutchouc, liberated at the earth's surface, to be recovered later if possible.

Paper balloons are spherical. Their diameters vary between 3 and 8 m. (14 up to 270 cu. m. in volume). The caoutchouc balloons are very similar to those which are given to children, but are of better quality and larger. Their normal diameters vary from 0.4 up to 2 metres.

During flights the diameter can reach from 6 to 8 m. before the caoutchouc will disrupt. The size most ordinarily used is 6 m. in diameter (113 cu. m.) for the paper balloons, and from 1.2 m. up to 1.5 m. for the caoutchouc balloons. The size necessarily depends on the instruments which it is desired to send up. In all cases the recording instruments used in such investigations, barometers, thermometers, hydrometers, etc., must be very light. To this end some special designs have been made.

These balloons are inflated with hydrogen in order that their lifting power shall be as great as possible relative to their volume. Of course, they rise with great rapidity at the commencement of their flight, from 4 up to 8 m. per second, reach their highest point, and return to the earth. Generally, the caoutchouc balloons explode at their maximum altitude. For that reason it is necessary to protect the apparatus and their valuable records against a destructive fall, for which is used an ingenious device; that is, the balloon is covered with a parachute arrangement, which, at the moment of exploding, opens and regulates the speed of descent. Many times two balloons are sent up, of which only one explodes; the second then remains intact and checks the fall.

If it is desired to take a specimen of the air, the balloon carries up finely pointed tubes, in which there is as near-

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ly perfect vacuum as possible; by means of a clock-driven device, the point is broken at will and is automatically reclosed some minutes later.

These explorations by sounding balloons are being made in all parts of the world, expeditions having crossed the Atlantic and Indian oceans; others have gone to Lapland and Greenland; others to the regions of the great African lakes. Flights are made regularly in nearly all civilized lands.

And now what are the general results of these numerous investigations?

At the sea-level the temperature somewhat regularly decreases in the first 2000 to 3000 m., often having inversions; later it cools more rapidly and regularly up to an altitude varying from 8000 to 14,000 m., according to the locality. In French regions, at approximately the altitudes named, there usually are observed the lowest temperatures. If the investigation is carried farther upward, the temperature is generally sensibly increased (a warm layer), and later decreases again very rapidly and irregularly. This layer, where the temperature is almost constant and does not have regular variations either way, is called the isothermal layer or stratosphere.

The Pavia balloon, which was mentioned at the beginning of this article, gave similar indications; there should be mentioned also the Belgium balloon, liberated on November 5, 1908, which registered –67.8°C. at an elevation of 13,500 m., and only –63.5°C. at 29,040 m.; and that sent from Trappes on August 10, 1907, which showed –55.6°C at 13,000 m. and –51.6°C. at 28,000 metres.

This division of the temperature is found commonly everywhere, changing only according to the meteorological situation in the temperate and polar regions, as shown by the following figures, taken from the works of Teisserenc de Bort, and obtained by investigations at widely differing latitudes:

Year 1901		Temperature at starting.	Minimum temperature.
March 9	Moscow	— 19.0°	— 55.2° at 8000 metres
" 9	Paris	+ 5.4°	— 48.8° " "
" 15	Moscow	— 7.3°	— 53.4° at 9300 "
" 15	Paris	+ 4.0°	— 50.4° " "

Or in comparisons between the observatory at Trappes and the station of Kiruna in Lapland.

1907		Temperature at starting.	Minimum temperature.	Temperature at greatest altitude.
March 14	Kiruna	— 12.1°	— 69.8° at 10,760 m.	— 66.6° at 14,080 m.
" 14	Trappes	+ 2.1°	— 63.8° at 11,150 m.	— 58.6° at 14,570 m.
" 26	Kiruna	— 4.6°	— 56.7° at 11,600 m.	— 53.2° at 15,600 m.
" 26	Trappes	+ 2.6°	— 61.9° at 11,980 m.	— 55.2° at 15,600 m.
" 29	Kiruna	— 1.0°	— 66.3° at 11,974 m.	— 51.6° at 17,000 m.
" 29	Trappes	+ 4.0°	— 60.6° at 11,450 m.	— 50.6° at 14,000 m.

A long time ago Teisserenc de Bort showed that the altitude of the stratosphere varied with the meteorological condition: low (8000 to 9000 m.), and warm (–45° to –55°), during atmospheric compressions it reaches higher altitudes and becomes colder in the anti-cyclones, where it can reach a temperature of –60° to –75° at an altitude of approximately 14,000 metres.

Another very interesting fact: only seldom are temperatures as low as –80° observed over the polar and temperate

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zones, while that temperature often is reached and even exceeded over the equatorial regions, where the stratosphere is found only at altitudes of from 16,000 to 18,000 m.; the observations made by Teisserenc de Bort over tropical seas and over Lapland during the years 1906, 1907, and 1908 showed that for the upper regions the temperature is less cold at the poles than in the equatorial regions, although upon the earth's surface the polar temperatures are the lower by from 20 to 50°. The atmospheric movements that take place at the equator produce, doubtless, powerful and sudden decreases of air pressure, which cause a lowering of the temperature.

Further, the temperature decreases more rapidly in the equatorial regions for the reason that the air is drier and it chills more completely, hence the stratosphere lies at a higher altitude; for that reason, approximately at 16,000 or 17,000 m., temperatures are observed from 20 to 30° colder above the equator than over Lapland.

Finally, the various observations made it possible for the Austrian meteorologist, Hann, to determine the consistence of the air at different altitudes: and that atmosphere, the components of which were given above as for the earth's surface, is not constant; only 18% of oxygen at 10,000 m., 15% at 20,000 m., and 7% at 35,000 m., while the quantity of nitrogen becomes greater, respectively 81, 84, and 93 per cent.

It would be difficult to remain indifferent in the face of such remarkable discoveries that lead to a more complete knowledge concerning the medium in which we live, making it possible that we shall more thoroughly understand the mechanism of the air movements. We owe much to the scientists conducting these investigations.

Inductive Interference Between Power and Communication Lines*

THE committee of engineers representing the electric wire interests of the state of California, authorized by the California State Railroad Commission, in December 1912, to investigate the subject of inductive interference between power and communication lines and to make recommendations for Commission rulings intended to prevent undue interference, reports progress up to September 1, 1913, as follows:

Since the first of the year a field force of from five to eight experimenters and computers has been engaged in collecting and computing data under instructions from the committee. The field force is equipped with a large amount of apparatus, including an oscillograph having three vibrators, noise standards, an impedance bridge, complete equipment for harmonic analyses, and instruments of various kinds, the total aggregating in value approximately $9000. Some of this equipment has been necessarily de-

*General progress report of the joint committee appointed by the California State Railroad Commission.

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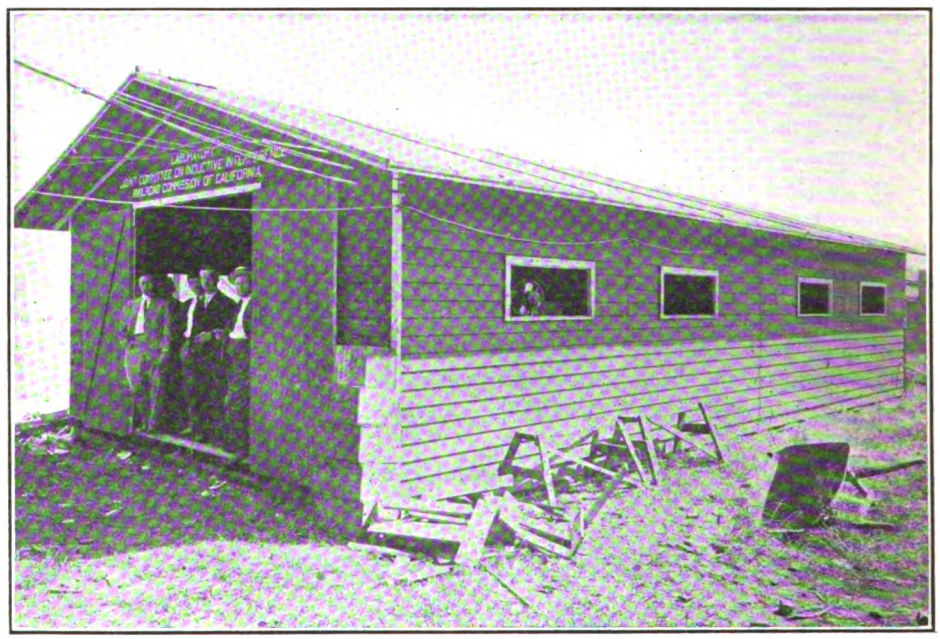
signed especially for doing this work.

Equipment is provided for harmonic analyses by either or both of two methods. The first involves the use of the oscillograph, the recorded waves of which are greatly improved for harmonic analysis by the use of a distortion circuit. This consists of a circuit containing inductance and capacity so chosen as to give distortion of the harmonics in approximate proportion to the square of the order of the harmonic. The second method of harmonic analysis is by means of the use of what is termed the resonant shunt. This consists of a circuit containing inductance and capacity so chosen that in combination with the capacity of the telephone line the whole circuit can be made to resonate for any particular frequency or harmonic, the magnitude of which it is desired to measure. The currents so obtained are too small for direct measurement by any instruments available or suitable for this purpose. For this reason, each current so obtained is passed through a telephone receiver, and the amount of noise given by same is equated with the noise in the same receiver produced by a current of the same frequency and of sinusoidal wave shape produced by a wave generator consisting of a Vreeland oscillator. The latter current is computed from the constants of a circuit supplied by a measured potential difference.



EXTERIOR VIEW OF JOINT COMMITTEE'S TESTING LABORATORY.

The noise standard above mentioned is an instrument designed to measure the volume of noise that is produced by the current induced in the telephone line. This is accomplished by equating the noise set up by this complex wave in a telephone receiver with the noise set up by a pure sine wave of known amplitude having a frequency of 240 cycles. This comparison, of course, involves in a large measure a

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personal element, but this is reduced in these tests by taking as a rule the average results of four observers trained to the work by experience.

The parallels on which this work has now been completed are four in number, all of which involve one telephone line. This is the main coast line trunk lead of the Pacific Telephone & Telegraph Co. (the Bell System on the Pacific Coast), between San Francisco and Los Angeles. These parallels are all in the counties of Santa Clara and Monterey, between San Jose and Kings City, a distance of approximately 120 miles. The telephone lead consists in the main of ten copper physical circuits, part of which are loaded and some of which are made up into phantoms. The high-tension portions of these exposures are as follows:

First—A 57,000-volt 3-phase line of the Sierra & San Francisco Power Co., approximately 20 miles long, between San Jose and Gilroy.

Second—A portion of the same line, approximately 8 miles long, running into Salinas.

Third—A 22,000-volt 3-phase line of the Coast Counties Gas & Electric Co., approximately 16 miles long, between Morganhill and Sargents, and overlapping the above-mentioned line of the Sierra & San Francisco Power Co. from Morganhill to Gilroy for a distance of approximately 10 miles.

Fourth—A 33,000-volt 3-phase line of the Coast Valleys Gas & Electric Co., approximately 40 miles long, between Salinas and Kings City.

All of the above power lines are operated at 60 cycles.

In all cases the telephone-pole line is on one side of a public highway and the power line or lines on the other side, with an average separation of approximately 60 ft. The power lines of the two separate companies overlapping as mentioned above, are erected one above the other. As these two power systems are operated from separate sources not in synchronism with each other, and as neither one can be shut down to enable the influence of the other to be independently measured, the difficulties of analyzing the inductive effects in this exposure have been enormously increased.

In order to eliminate the effects of induction from other power systems on through telephone circuits, and from them to lines under test in the various exposures, it is necessary to cut all telephone circuits on the lead at the two ends of the exposure under test. Since the telephone lead is a main line of vital importance to the system of the telephone company, it has been necessary to make practically all tests between the hours of 10 p.m. and 6 a.m.

Since the line of the Sierra & San Francisco Power Co. between San Jose and Salinas is the only source of electric power for the greater part of Monterey county, it has been impractical to suspend service on this line for obviously desirable special tests, such as single-phase short-circuit runs with ground return, the application of single-phase potential to ground or open circuit, etc., except on the rare occasions of general changes made by the power company, thus increasing the difficulties of the investigation.

The system of the Sierra & San Francisco Power Co. is operated with a solidly grounded neutral, and facilities were available for readily grounding the neutral of star-connected main transformers in the sub-station at Salinas, or removing the ground connection. This has enabled a thorough comparison to be made of the inductive effects of this system: first, with a neutral ground beyond one end of the exposure; second, with a neutral

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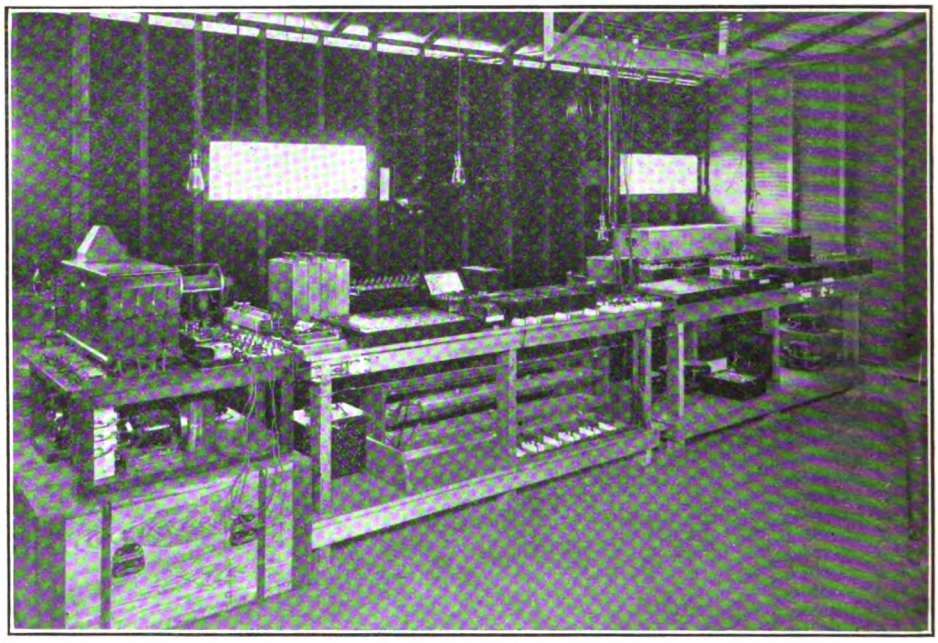
ground beyond each end of the exposure, the latter condition giving a return path through ground for unbalanced currents in the line conductors. The system of the Coast Counties Gas & Electric Co. is operated without a grounded neutral, making it possible to obtain a certain amount of comparative data between grounded and ungrounded systems, the comparison being limited by the facts that the two systems are of different voltage with different lengths of exposure largely overlapping, different sizes of conductors, different spacing of power wires, and other variables.

Thorough investigations have been made of residual and balanced currents and voltages in the power systems, of the shielding effects of other wires on the telephone lead, of the existing transposition systems in both the power and telephone lines, and of the relative locations of the power and telephone transpositions; also of the effects of modifications of these transposition schemes.

Throughout parts of the above exposures of the telephone line, the same power lines parallel the Western Union telegraph wires and the signal circuits of the Southern Pacific Co. on the railroad right-of-way of the latter company. The effects of the power lines on these circuits have been included in the investigation.



INTERIOR VIEW OF LABORATORY SHOWING TESTING APPARATUS.

The analyses of the inductive effects have been laborious on account of the large number of different forms of induction in action simultaneously. These may be listed as follows:

1. Segregation — Electrostatic and electromagnetic.
2. Segregation—Effects of balanced and of residual currents or voltages.
3. Segregation — Longitudinal and transverse induction.

The terms used by this committee

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under the above third segregation may be defined as follows:

Longitudinal induction is that which sets up an e.m.f. between a wire and ground, or a current through a wire with a ground return; transverse induction is that which sets up an e.m.f. between two wires, or a current in a circuit made up of two wires without a ground connection. It is obvious that in the case of a phantom circuit the transverse induction is that between the two sides of the phantom, each consisting of two wires. It is also obvious that in general the transverse effect is the difference between the longitudinal effects on the two sides of the circuit. It is also obvious that the transverse induction is that of chief interest from the standpoint of interference with telephonic transmission.

Referring to the above segregation, attention may be called to the fact that each form of induction, transverse and longitudinal, is due in part to electrostatic and in part to electromagnetic influence, and that any one of these four effects—tranverse electrostatic, transverse electromagnetic, longitudinal electrostatic, and longitudinal electromagnetic—is due in part to the balanced currents or voltages and in part to residual currents or voltages. In order to make a complete study of the effect of transpositions, each of the eight effects must be considered independently. The transposition problem is further involved by the necessary transposition system of the telephone wires between themselves to avoid crosstalk, which in itself is elaborate on a heavy lead.

In the case of the exposures so far investigated, it has been impossible to get enough transverse induction under normal operating conditions to obtain oscillograph records of sufficient amplitude for harmonic analysis. The study of the transverse induction has therefore been limited to the results obtained from the noise standard and the use of the resonant shunt apparatus. A difficulty introduced by this condition is that the use of the resonant shunt apparatus involves successive measurements of the several harmonics. Between the times of these measurements the load on the power system may and does vary, and, what is more essential, the shape of the waves of the power system and particularly of the residuals and of the neutral current of same varies.

On the whole, the investigation, so far as the currents and voltages of the power system are concerned, has resolved itself into a determination of the relatively small difference between almost exactly equal quantities, that is, into a determination of the residual voltages and currents which are minute compared with the main voltages and currents. This has involved an elaborate study of the errors introduced by the use of the necessary current and potential transformers, and particularly of the effects of same on the higher harmonics. As might be expected, the work of computation and the analyses of the data obtained greatly exceed the work of actually making the tests.

The joint committee has a membership of fifteen engineers, part of whom represent the power interests, part of communication interests in the state of California, and part the State Railroad Commission. The necessary funds for the work have been voluntarily contributed by the power and communication interests of the state. A large amount of the apparatus used has been loaned by the Pacific Telephone & Telegraph Co., some has been purchased by the committee, and a relatively small amount, consisting of current and potential transformers, oil switches, etc.,

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has been loaned by the power companies.

So far as can be determined by the members of the committee, no investigation of these complicated phenomena has ever been undertaken heretofore on a scale comparable with that of this work either in magnitude or in the matter of thoroughness. The study has developed into an investigation of much greater scope and complications than was originally anticipated.

Although eight months have already been spent on this work, which has not been allowed to drag, but has been pushed continuously and as rapidly as possible without detriment to the work, the investigation has not as yet been made on a sufficiently large number of exposures of different characteristics to allow of any general conclusions. No statement can as yet be made regarding the recommendations of this committee on this set of exposures, since these recommendations have not as yet been presented to the State Railroad Commission. While the complications of the problem now appear to those carrying on the work so great as to make extremely difficult the drafting of general remedial measures which shall not be onerous on the interests involved and shall not be subject to so many exceptions and alternatives as to make them ineffective, the committee expects that with sufficient time and financial assistance this work can be made to serve as a basis of rulings which will be not only helpful to the communication interests, but also to the power interests in the way of standardization of construction and operating methods and the reduction of interruptions to service.

Members of the committee also feel that, more important than the above, the work will enable the Railroad Commission to make rulings which will in future reduce harmful agitation, legislation, and litigation.

Huntington Drive

By ERNEST F. AYRES*

CONSIDERABLE data have been published on the cost of concrete roadways and concrete base for brick, asphalt, wood block, and similar pavements, but little information is available concerning the concrete road with a thin asphaltic oil wearing surface. The Los Angeles Highway Commission has had accurate records kept on each item of expense in the Huntington Drive contract which will be valuable as a basis for figuring preliminary estimates on this type of construction.

The concrete base has been adopted as a standard for main traveled highways by both the state and county highway commissions, but the difficulty of repairing a concrete surface, together with its non-resiliency, made it imperative that some form of wearing coat be used for surfacing. After an exhaustive study of the different pavements, Frank H. Joyner, the chief engineer, decided upon a 5-in. concrete base pro-

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tected from abrasion with one-quarter gallon of asphaltic oil per square yard. The oil was applied at a temperature between 180 and 250°F., and covered with screenings, forming a wearing surface which affords a good foothold to horses, and is non-slippery, slightly resilient, and easily maintained with an inexpensive plant. The only question is whether it will stick to the concrete or peel off in hot weather.

Itemized costs are shown in the following summary:

Huntington Drive, Div. 37, Sec. 1. Alhambra to Valley Road.

Length, 2.39 miles; width, 20 ft.; thickness, 5 in.; area, 28,280 sq. yd.

COST TO COUNTY FOR CONSTRUCTION OF CONCRETE PAVEMENT WITH BITUMINOUS WEARING SURFACE.

Item and quantity.	Unit price.	Amount.	Per sq. yd.
Excavation, 2997 cu. yd	$0.50	$1,498.50	$0.0564
Overhaul, 9546 sta. yd	0.01	95.46	
Shaping roadbed, 12,645 lin. ft	0.09	1,138.05	0.0402
Concrete, class A, 32.88 cu. yd	9.00	295.92	0.0182
Steel, 1310 lb	0.04	52.40	
12-in. reinforced concrete pipe, 221 lin. ft	0.75	165.75	
Concrete pavement, 28,280 sq. yd	0.489	13,828.92	0.4890
Total paid to contractor		$17,075.00	$0.6038
MATERIALS FURNISHED BY COUNTY.			
Cement, 5951 bbl	$1.55	$9,224.05	$0.3262
Oil, 172.86 bbl	1.382	238.98	0.0084
6 grates for catch basins	6.00	36.00	0.0012
Total cost of road		$26,574.03	$0.9396
Inspection		1,086.73	
Engineering		263.53	
Total cost, including inspection and engineering.		$27,924.29	$0.9874
Overhead charges (approximate)		1,300.00	
Grand total cost		$29,224.29	$1.0334

COST TO CONTRACTORS, NOT INCLUDING OVERHEAD CHARGES.

Items and quantity.	Amount.	Per sq. yd. of pavement.
Excavation, 2997 cu. yd	$1,435.32	$0.0507
Shaping roadbed, 12,645 lin. ft. 20 ft. wide	1,455.69	0.0515
Cost of lumber, 26,000 ft. B. M	596.25	0.0211
Cost screened gravel, 3723 cu. yd	1,861.60	0.0658
Cost sand, 1,758 cu. yd	545.25	0.0193
Hauling lumber, 26,000 ft. B. M	239.69	0.0085
Hauling screened gravel, 3723 cu. yd, 6 miles	3,185.76	0.1126
Hauling sand, 1758 cu. yd, 6 miles	887.51	0.0314
Hauling cement, 5951 bbl., 1½ miles	576.15	0.0204
Hauling miscellaneous	84.38	0.0029
Water, 7 gal. per sq. yd	13.49	0.0005
Mixing and placing concrete	2,086.22	0.0738
Hauling and spreading oil, 172.86 bbl	51.86	0.0018
Cost of screenings, 180 tons	153.00	0.0054
Unloading, hauling, and spreading screenings	99.00	0.0035
Total	$13,271.17	$0.4693
Total per square yard		$0.4693

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PETROLITHIC ROLLER FOR TAMPING SUB-GRADE.

LOADING-END OF SELF-PROPELLED CONCRETE MIXER.

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MATERIAL, QUANTITIES PER SQUARE YARD.	
Cement	0.2104 bbl.
Screened gravel	0.1316 cu. yd.
Sand	0.0622 cu. yd.
Water	7.0000 gal.
Oil	0.2562 gal.
Screenings	0.0063 tons.

The total cost, exclusive of inspection, engineering, and county office expenses, is much less than is usually paid for a high-class pavement, and it is estimated that the road can be maintained indefinitely for 1c. per square yard per year. The cost of the surfacing is practically negligible—0.84c. for the oil, 0.18c. for hauling and spreading, and 0.89c. for the screenings in place complete; a total of but 1.91c. per square yard. The item of heating oil does not appear in the tabulation, but this is probably included in the cost of spreading. If not, the total cost would not exceed 3 cents.

The cement, furnished by the county, was considerably cheaper than the usual market price through the state. The road was situated near the mills, and the cement companies made a special figure for this improvement. The contractor also estimated very closely, probably more so than he would care to do again. On the face of the figures, he made a profit of 22% on the $17,075 paid, but the summary does not include his overhead charges, depreciation of plant, interest on investment, and incidentals. He received $1498.50 for excavation and $95.46 for overhaul, a total of $1593.96, and it cost him $1435.32, not counting overhead charges. For shaping roadbed, he received $1138.05, and it cost him $1455.69.

During the month of November an increased efficiency of the concrete-mixing gang was obtained during the first two weeks. The maximum efficiency was not reached, however, until January 20 and 21, when the record run was made, one batch in 2.2 minutes, or 7.27 cu. yd. per man per 8-hour day. The average run was but 5.16 cu. yd. per man.

The following summary shows the amount of each mix used on the job:

Mixture.	Sq. yd.
1:2:4	19,096.4
1:2.35:4	568.9
1:2:4.27	624.4
1:2:4.5	1,324.3
1:2:4.6	711.1
1:2:4.67	644.4
1:2:4.9	588.9
1:2:5	4,710.7
Total	28,269.1

Only on one day, December 7, was the amount of sand increased, while the stone was changed frequently until December 13, when the 1:2:4 mixture was used until the completion of the contract.

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The Kammerer Method of Cementing Off Water in Drilling Oil Wells

By ROBERT W. PHELPS*

THAT a number of articles have been published recently in respect to the ever perplexing water problems in the oilfields of California, plainly illustrates the interest and coöperative effort on the part of oil operators to overcome or minimize this difficulty. These articles may be roughly divided into two classes, namely: (1) those bearing on the particular place, relative to the water and oil-bearing strata, to shut off the water; (2) those bearing on the particular method of shutting off the water. This article will be within the second class.

The earlier oil wells of California used the old method of driving the casing into a soft or sticky, and necessarily impervious, stratum of shale or clay. A more detailed description of this method is essential to fully appreciate the evolution that has come about in handling the water problems in drilling wells.

In the early days, rotary tools were not used, the standard cable tools being alone in the fields. After the last water-bearing stratum had been penetrated, and before the oil-sand had been reached, the driller sought a suitable formation to 'drive' the casing. When this formation was reached, the casing was allowed to rest on the bottom of the hole. The hole was reamed to this depth and the casing should be free. Drilling was then continued, and the casing, unsupported, was allowed to settle, or follow the bit, as it is known in the fields, as far as it could before the friction of the smaller hole was greater than the weight of the casing. Drilling progressed a little farther and the casing was driven as far as was deemed safe. Fig. 1 shows the result of this method. The dotted lines indicate the development to be done after the water has been shut off.

During that period the holes were not drilled so deep, and this method was found to be satisfactory for a time at least, though often water seeped its way down between the walls of the hole and the casing after a year or more. Later, when oil was discovered at greater depths, the above method was found to be inadequate. The great weight of casing bearing down on the shoe, in addition to the continued soaking from the water above, and constant jarring to which the pumping apparatus subjected the casing, forced the driller to find a more solid and permanent method, and so the cementing process was evolved.

In the cementing process, as it is commonly practised, the cement is run in back of the casing, forming an impervious ring, filling the space between the casing and the walls of the hole. To do this, the hole is reamed to the bottom, which is preferably a hard shell. The casing should be free to be

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moved and it should be possible to circulate water down the inside of the casing to be cemented and up at the outside. The casing is raised one joint and tubing inserted just a little short of the depth of the casing. Cement grout of the consistence of thick cream is pumped to the bottom and will go up the outside about 50 ft., depending upon the amount of cement used, the top of the casing being tight. When the cement is all down, the casing is lowered to the bottom and forces more cement in back of the casing. The tubing is removed and the cement remaining on the inside is bailed out before it can set. Fig. 2 illustrates the result at the end of cementing. The dotted line indicates the subsequent drilling.

There is not space in this article to go into all of the details, and no pretense is made in the brief description above. The above method, with varying detail, has been very ably described in a number of papers recently, and I shall pass over the above method of cementing after bringing out one or two important points.

Until the cement sets it is held back by the bottom edge of the shoe resting on a hard formation. Equal columns of water inside and outside of the casing are sought, but there is one point that probably makes them unequal. The mud settles toward the bottom and as circulation takes place, both in the trials and in forcing the cement back of the casing, this mud is apt to be much thicker outside of the casing than in, so that the columns of fluid inside and outside the casing may be of the same height, but exerting appreciable differences of pressure at the bottom of the casing, and thus causing the cement to have a tendency to be forced back inside of the casing. Failures due to this cause alone, of course, are purely problematical.

In the spring of 1909, William Kammerer, of the West Coast Oil Co., evolved a method which combined the older method of driving the casing and the newer method of cementing and

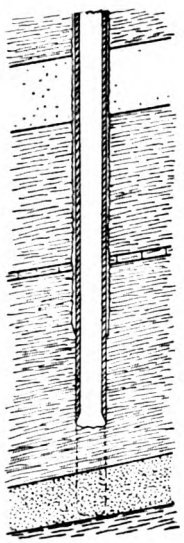

FIG. 1.

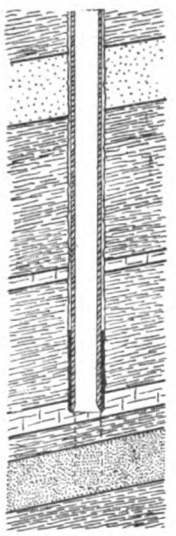

FIG. 2.

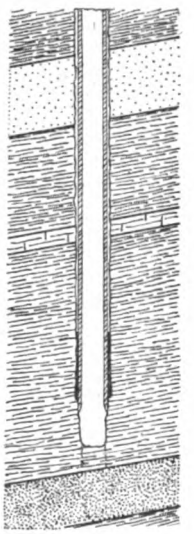

FIG. 3.

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retaining and combining the best points of both. In the first place, the hole is drilled with the rotary until the bit has reached a sticky shale at a desirable depth. It is essential in the Kammerer method to land the water string —that is, the casing to be cemented— in an impervious sticky shale; and, of course, no water-bearing strata should be between the point of cementing and the oil-sands. By using the rotary drill, a hole of sufficient diameter is carried to the depth of cementing. The water string is usually 10-in. casing.

When the rotary bit has reached the depth and the sticky shale, the drill pipe is removed from the hole and placed standing in the derrick. The 10-in. casing is run into the hole with a shoe 14 inches in length on the bottom. The casing should move freely all the way to the bottom of the hole. There is apt to be trouble in starting circulation at a great depth; consequently, after 1200 to 1800 ft. of casing has been put into the hole, the circulating pumps are connected and circulation kept up until all the casing is in the hole.

A string of casing as long as 3000 ft., which is more than common, measured necessarily before it is screwed together, is not apt to check in measurement of the hole with the sand-line which stretches, and is corrected for taking out bad or worn parts, etc.; consequently, when the 10-in. casing apparently reaches bottom, the 10-in. standard bit is run in the hole and 12 to 18 in. additional hole is drilled. If the casing follows the bit, it is safe to say that it is resting on bottom, and a mark is made on the casing opposite the floor, so that upon raising the casing later and lowering to the bottom, the bottom is assured.

The casing is now tested to see if it is water-tight. With the casing resting on the bottom, the top of the casing is connected with the pumps by means of a flexible and suitable connection. If, upon starting the pumps, the pressure at the pumps runs up and no water comes up the outside of the casing, it may be assumed that the pipe is tight. The pipe should be raised about a joint to make sure that circulation is possible.

The next step is where the Kammerer method diverges from the commoner methods of cementing. With the casing raised a joint, the circulating pumps disconnected, and the casing suspended on the clamps, the top joint is removed. The standard 8-in. bit is used in drilling the hole about 3 ft. deeper. This little hole is known as the pocket hole. The cement is now mixed in a box of suitable size for mixing about 1500 lb. (dry weight) of cement with water to a consistence of thick cream. The mixing box is placed temporarily on the floor of the derrick so that the sluice gate is a little above the top of the casing.

A special dump bailer is used in lowering the cement to the bottom of the hole in preference to pumping it down tubing. This dump bailer is 72 ft. long and will take the 1500 lb. of cement mixed and just be full. Before filling the dump bailer the water in the hole is bailed to a depth of 80 or 90 ft., so that none will run in at the bottom and replace any cement.

After the valve and dumping device on the dump bailer has been thoroughly cleaned and inspected, it is lowered into the hole until the top comes just below the sluice gate of the mixing box, and the liquid cement is poured in. It should be full before lowering to insure that it is holding the cement.

The dump bailer should be lowered carefully. The impact between the water and the bottom of the dumping

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device is apt to cause it to open if too great, and the presence of the water forcing its way up past the dump bailer as the latter goes down might have the same effect if too great.

Upon reaching bottom, the dump bailer should touch the bottom of the hole two or three times to insure that the dumping valve has opened. The dump bailer is then brought to the surface to receive its second and third loads. Before each load the valves should be washed to insure that they will open when at the bottom. The second and third loads should be mixed while the dump bailer is making its round trip.

Water will probably have to be bailed after the first and second loads, as the cement will replace an appreciable amount at the bottom. The third load will make a total of dry weight of cement used of about 4500 lb., which has been found sufficient.

The joint of casing previously removed is then screwed on, and the circulating pumps connected and started. The circulation starts and as soon as the water begins to come up the outside of the casing, the latter is slowly lowered until the mark indicates that the shoe is resting on the shoulder or an inch or two below. As soon as the casing shoe comes down on the shoulder, the circulating is stopped and the pressure at the pumps run up. The pumps are now stopped and disconnected. The casing is then driven down from 3 to 8 in., the pocket hole facilitating the driving, but the casing is not driven so hard or far as to run the risk of collapsing. The cement in its liquid form as well as the water are now sealed outside of the casing, the former has nothing to cause agitation, and everything in favor of setting solid and making a 'tight job.'

The sand bailer is now run in and all of the cement inside the 10-in. casing is bailed out before it can set. About 2 ft. in depth of cement is the average amount left inside, so it can be seen there is not a great deal wasted, the greater part going outside of the casing where it belongs.

After four or five days, the 10-in. standard bit is run into the hole and the remaining cement which was not picked up in the bailer is drilled out and the hole deepened about 25 ft. beyond the casing. Then the water on the inside of the casing is bailed down as far as is deemed safe from the standpoint of the casing collapsing from external pressure. After bailing, the water is allowed to stand for 24 or more hours. The water should stay very near the level, though it might rise 10 or 15 ft., caused by the water dripping down the sides of the casing after bailing. After coming up that amount, it should remain constant.

Since the spring of 1909, about fifty new drilling wells have been cemented by the Kammerer method in the Salt Lake and Coyote oilfields, and out of the fifty, every cementing job has proved tight. It might be said that it was 'luck,' but the fact is that it was the method used plus the care and skill of the operator that brought about the desired result.

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The Canalization of the Columbia and Snake Rivers*

By JOHN H. LEWIS†

NOW that there is a prospect of the early completion of a 40-ft. channel across the Columbia River bar, it is important that definite plans be made for connecting the various links in the 2100 miles of navigable waters tributary to this outlet. This is all the more important in view of the stimulus to water transportation which will be afforded by the Panama canal and the public dock facilities now being provided by the various coast cities.

The time appears ripe for a concerted movement for the improvement of navigation facilities for the benefit of every section of the 254,000 square miles of territory tributary to the Columbia River bar. This stream should be treated as a unit, from its source to its mouth, and a comprehensive plan of development should be worked out at the earliest possible date. Such plan should take into account the use of water for navigation, irrigation, power development, and other purposes. If we insist that the entire cost of such improvements be charged to navigation, as in the past, we will probably never secure the desired result, for the reason that our problems are much more difficult of solution than in the canalization of the Ohio and other streams where the river traffic is very great. We have, therefore, an unusual problem, which must be solved in an unusual way. The unusual feature is the enormous quantity of water power which can be developed incidental to navigation. The problem, therefore, is to find new uses for this unused power.

The development of this vast empire seems to me to be progressing backward in the most discouraging manner to the farmer on whom we are dependent for its final accomplishment. The first step in a program for national irrigation should have been to provide a national system of water or rail transportation for the marketing of products raised on the vast irrigation projects. This is the Australian plan. The credit of the nation or state is used to provide cheap transportation for the farmers whom they ask to settle on government irrigated lands. The roads necessarily operated at a loss the first few years, but now I am informed that 6% is being earned on money borrowed by the nation at 4%, and the farmer gets his products to market at low cost.

I am informed by a discouraged citizen of the great Snake River basin in Idaho that he sold this year 600 tons of alfalfa hay at $3.25 in the stack, and that he knows of much hay in his community which has been sold as low as $3 per ton. The cost of cutting and stacking is about $1.25 per ton, and

*For Columbia-Snake River Waterways Association, Kennewick, Wash., Sept. 25, 1913.
†State Engineer, Salem, Oregon.

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for baling and hauling 6 miles to the railroad about $3 per ton in addition. It is no wonder that many of the private irrigation projects are in financial difficulties, and it will be difficult for the settlers on the Government projects to pay out, even though no interest is charged.

What transportation means to the farmer can be expressed briefly by the following figures, which are approximately correct: One dollar will pay for carrying 1 ton 15 miles on an efficient wagon road, 150 to 300 miles on an efficient railroad, 1500 miles on inland deep waterways, and 2000 to 3000 miles on the ocean.

His market radius will be extended by inland waterways five times farther than if dependent on railroads alone, and about ten times farther if accessible to the ocean.

Why should we continue to send out carloads of fancy colored literature so that we may get farmers upon the land to undergo a long period of suffering, when three Northwest states have at their command enormous credit resources which could be used to relieve the situation? Having cheap transportation in advance of settlement, our problem of development would be easy. Why is it necessary to await appropriations by Congress when we have an enormous reservoir of credit in the $2,000,000,000 of assessed valuation of these three states?

If cities have learned to loan the credit of all the people to furnish economical street pavements, water supplies, and electric light system, why should not the people of the great Columbia basin loan their credit to provide economical water highways for the rapid and economical development of this region? If the various states could coöperate, each with the other, and with the United States, the problem will be simple. Future generations would be glad to bear their part of a debt incurred for such purpose, as the life of their pioneer fathers would have been made more easy. The burden distributed over many years would be small.

The Columbia River basin could compete with the world for those industries supplying world markets, where cheap electrical power and cheap transporation are the essential factors. I believe it safe to say that there is more undeveloped water power within economical transmission distance of the city of Portland than within a like distance of any other city in the world of its size, similarly situated on tidewater. If The Dalles water-power project, now under investigation by the state of Oregon, can supply thirteen times the power now used by Portland and the surrounding territory, then it is but natural to inquire as to what uses such enormous quantities of power can be put.

Mr. Vanderlip, of the National City Bank of New York, recently stated that "Two billion dollars could be invested with profit, in the electrical industry of the United States, alone, in the next five years—an amount equal to $8,000,000 of fresh capital every week." This statement was based on existing statistics. When you add to these figures the capital needed in these new industries dependent upon the use of cheap power in the electrical furnace, these figures become truly staggering.

"It would require a capital investment of $860,000,000 to assure the production of an amount of nitrate fertilizer from the air, equal to that now consumed by the civilized world," according to Mr. Norton, one of the experts of the U. S. Department of Commerce and Labor. There is enough nitrogen in the air over one square mile

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of the earth's surface to supply the world for fifty years at the present rate of consumption. A single company in Norway is now using 200,000 hp. and 2000 men in this industry. One-fourth of its output is now shipped around the Horn to California and Hawaii in competition with the natural fertilizer from Chile. This company's market is said, on good authority, to be growing at the rate of an 80,000-hp. plant every year. About 1.6 hp. year is required to produce one ton of fertilizer. The Cyanamid Company of Niagara Falls is now operating six 3000-hp. electric furnaces in the production of a nitrogen ammoniate fertilizer, using current at about $15 per horsepower-year. The market for the product is said to be increasing faster than men can be educated to carry on the work. Enormous quantities of electric power will, in the near future, be used in the manufacture of iron and steel, and in the smelting of copper, zinc, and other ores.

Iron and steel can be produced in Portland cheaper than in Pittsburgh, according to figures furnished by Mr. Potter, former superintendent of the Illinois Steel Co.'s plant in South Chicago, if electric power at low cost can be had. A high-grade iron ore from China can be landed on the Portland docks for 7c. per unit of iron, in comparison to 8c. for Lake Superior ore in Chicago. With power at $9 per horsepower-year, electric steel rails could be manufactured at $17.50 per ton, where the regular price is about $40. As electric steel rails have been found to be almost unbreakable in service, they are now commanding a premium of from $6 to $10 per ton over open-hearth and bessemer rails, according to the same authority.

The capital cost of an electric iron and steel plant is about one-third that for a coal-using plant. This fact is of great importance to the West. Ore can be obtained from Mexico, Chile, Cuba, or other points if the Chinese supply should prove unavailable. Pig iron is now being produced by the electric process in Shasta county, California, at about $14 per ton where the same grade at Pittsburgh costs $17.25 per ton. Charcoal equal to one-third the weight of the ore used in the electric furnace, must be had for this industry. As about two cords of fir wood is required for one ton of charcoal, a market can thus be had for our waste wood products. Cheap electrical power can also be used to convert this wood into charcoal. For six years such an electric process plant has been in successful operation at Vancouver, British Columbia, using waste wood from sawmills.

As a result of experiments by the U. S. Bureau of Mines, it is stated that "There is no reason metallurgically why electric heat may not be substituted for the heat derived from the combustion of carbon in the smelting of copper ores. It depends largely upon the relative cost of coke and electric power. Coke and electricity are about on a par when coke costs $7 per ton and electric energy 0.15c. per kilowatt-hour, or about $10 per horsepower-year." Zinc ores are now being shipped from Australia to Norway for smelting in electric furnaces, and in Tasmania a 200,000-hp. plant is now under construction for the smelting of the complex ores of that region.

The foregoing statements should be sufficient to convince one that there is a very large market for the employment of cheap electrical power in many new industries which are not now in the field. I will next point out briefly the amount of undeveloped water power available on the Columbia river and Snake river to Huntington, and state what I believe to be the necessary

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steps to secure its development.

At Cascade Locks, 190,000 water horse-power can be developed at low stage of the river by the construction of a 10-ft. dam at the head of the rapids and a canal in Washington less than 1000 ft. in length. The low water head of 24 ft. will thus be increased to 34 ft. Such a dam will greatly improve navigation conditions between Cascade Locks and Big Eddy. The high water head will be only 14 ft. Sufficient water will, however, be available to maintain the required power output. By removing a number of obstructions to navigation in the stream below, the power possibilities at this point would be somewhat improved. At Big Eddy, 536,000 hp. can be developed for eight months in the year, which plant will deliver 300,000 continuous electrical horse-power, according to a preliminary report made by the state engineer. The cost is estimated at $77 per horsepower, and low-tension power can be furnished in the vicinity of the plant at $6.90 per horsepower-year.

A dam approximately 180 ft. high completely closing the present river channel, and a canal 1½ miles in Washington will afford a head of 85 ft. at low water and 32 ft. at extreme high water. Owing to difficulties in turbine design, only a range from 42 to 73 ft. of this head will be needed to give the above results. This will afford ample leeway for construction of the Cascade Locks power project and still leave room for some storage above the upper project to carry peak loads. This proposed dam, at the head of Five Mile rapids, will place Celilo falls 10 ft. under water and drown out 6½ miles of the navigation canal now being constructed by the United States around this obstruction. The lower 1½ miles, containing three locks, can be used in connection with the power project, the boats entering the wide open river immediately above the dam. This project, if constructed, will likewise benefit navigation for many miles upstream. The state of Oregon has appropriated $15,000 for a more detailed investigation at this point, and authorized coöperation with the state of Washington, and with the United States.

With the completion of the Celilo Navigation canal, the Columbia river will be navigable, with more or less difficulty, to Priest rapids, 198 miles above Celilo. The Snake river is now navigable, with some difficulty, from the Columbia to its junction with the Grande Ronde river, a distance of 167 miles. These minor obstructions can be easily overcome by low dams, constructed entirely at the expense of water-power projects. President Roosevelt vetoed a water-power grant which if developed would have greatly facilitated navigation to Lewiston, because it was thought such grant did not properly safeguard the people's rights. In the 27 miles between Lewiston and the mouth of Grande Ronde river we have a total fall of 110 ft., or 3.8 ft. to the mile. From the Grande Ronde river to Homestead, which point is 4 miles below the Ox Bow power project, now under construction, is a distance of 96 miles. The Snake river falls 930 ft. in this distance, or 9.7 ft. per mile. It flows through a narrow rock-walled canyon not more than 400 ft. wide, as shown by the maps of the Army engineers which are available, as far as Pittsburgh Landing, 77 miles above Lewiston. In the 59 miles between Homestead and Huntington, there is a fall of 250 ft., or 4.2 ft. to the mile. The banks are not so precipitous in this portion of the river.

In the 182 miles between Lewiston and Huntington, there is thus a total fall of 1290 ft. Much of this can, no

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doubt, be utilized for power development, incidental to the improvement of the river for navigation. The balanced piston type of lock, or incline cableway, can be used with little loss of time by boats going over the water-power dams. Ten thousand second-feet of water will be available at low stage for the first high dam to be erected just above the junction with Grande Ronde river. This for a 200-ft. head would develop 227,000 continuous water horse-power. Assuming bedrock to be found 100 ft. below the water surface, or 90 ft. below the bed of the stream, it is not believed that the dam will cost to exceed $40 per electrical horse-power. Estimating $35 for powerhouse and equipment will bring the total cost to $75, which is a very low figure. Industries situated at this site could have both rail and water transportation to the markets of the world.

This dam would create a slack-water pool over 20 miles in length and afford water transportation to the next dam above. At such site only 5000 sec-ft. of water will be available, which is approximately the amount passing Huntington. In this way it is estimated that 800,000 electrical horse-power could ultimately be developed between Lewiston and Huntington. If any use can be found for this power, a construction charge of $100 per horse-power would be most reasonable. It would thus yield $80,000,000 for construction purposes, making the river navigable at no expense to the people. Ignoring this water-power value, there is no hope of ever securing navigation for the upper Snake River valley in Idaho and Oregon. It is the duty of these two states, in coöperation with the United States, to investigate thoroughly the feasibility of this project before conditions become more complicated through the construction of railway grades near the water surface of the stream.

The first and most important step, in my opinion, for the canalization of the Columbia and Snake rivers is the creation by Congress of a National Water Board, having complete jurisdiction over all interstate and other waters under the jurisdiction of the United States, and which are beyond the control of the state water authorities. Such board should have power to protect the public interest and make definite grants on such terms as may be specified by Congress. The revocable permit and indefinite water-power tax imposed by the nation and state should be eliminated, unless it is the plan to undertake all such development at public expense. Pending such legislation, the various states should amend their constitutions so as to utilize the public credit, if necessary, to secure development.

Each state should erect a demonstration power-plant and furnish free power for a number of years, during the experimental stage of the various new industries which may be attracted by such conditions. The electric iron and steel industry was established in Norway by such method. As soon as the industries are on a paying basis, the price of power can be equitably adjusted, and the information gained during the operation can be used as a basis for the enactment of more enlightened state and national laws relating to water power.

In 1914 the people of Oregon will vote upon a constitutional amendment authorizing the issuance of bonds equal to 2% of the assessed valuation of the state for the purpose of irrigation and water-power development, and for developing the cut-over timber lands of the state. Washington and Idaho should take similar action.

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The Engineering Digest

Fuel and Lubricants for Internal-Combustion Engines*

By B. H. ARNOLD

AS experience with internal-combustion engines has been based to a great extent upon those of the widely distributed automobile and motor-boat types, the popular idea of gasoline is that of a fuel which can be successfully used in automobile and motor-boat engines. Until recently but little has been known of gasoline, and its low price and the fact that the majority of users purchased it in small quantities offered no incentive for its investigation. For many years previous to the advent of the gasoline engine, gasoline was a by-product in the manufacture of kerosene, and its disposal a problem to the refiner.

Conditions are now reversed, for the large number of gasoline engines has created a big demand for gasoline, and kerosene is being over-produced. This demand has increased the price of gasoline to such an extent that many engineering societies are investigating both engine design and petroleum refining with the idea of securing lower fuel costs.

Gasoline and its associate naphtha are generally known to be volatile, colorless, and inflammable distillates of crude oil or petroleum, graded and sold by some gravity method, usually the Beaumé scale. The higher a gasoline tests by this scale the more desirable it is supposed to be. This method of grading is, however, inaccurate and misleading, and where definite information is desired of the characteristics of any distillate, it must be superseded by the method based upon fractional distillation. If all other conditions were equal, the gravity method would be a fair means of comparison, but at the present time when these distillates are obtained from petroleum of many fields and having different characteristics, it is a fact that gravity by the Beaumé or any other scale tells very little of the relative suitability of various gasolines or naphthas. In order to show the reasons for this and the meaning of fractional distillation, we will discuss briefly the antecedents of gasoline and naphtha, as well as their use. This discussion is to be considered under the following heads:

1. Petroleum, Its Occurrence and Composition.
2. Refining of Petroleum.
3. The use of Gasoline and Naphtha in the Engine.
4. Specifications and Purchase.
5. Possibilities of Other Liquid Fuels.

1. Petroleum, Its Occurrence and Composition

The U. S. Geological Survey issues each year a bulletin containing complete figures in regard to the United States' production of petroleum and that of the last ten years of other countries. Those interested are referred to this bulletin, which will be supplied *gratis* by the Survey.

Petroleum has been found in all parts of the world, without any definite scheme of distribution. An inspection of any map indicating the distribution of the world's known petroleum fields will show that practically all of the producing regions are in or near civilized communities. From this, it is believed that those regions not now producing contain much oil as yet undiscovered, rather tnan that these regions are barren, as some would have us believe. Regardless of recent newspaper comments on the decrease of the world's petroleum pro-

*Abstract from *General Electric Review*, October 1913.

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duction, it is believed that while the production may not be increasing in proportion to the demand, the trouble is largely due to lack of transportation facilities and not to any immediate limitation of available source of supply.

Recently published articles have announced the discovery of large quantities of petroleum in various South American countries and of enormous quantities in North China. Mexico's great production record has been common property for some time. During the next two or three years the opening of the Panama canal and the increase in number of tank steamers and pipe-lines will make available these great supplies and have much effect on the price of crude oil.

Chemical analysis shows that crude oil is a very complex mixture of a large number of chemical compounds, which can be arranged in eight groups or series, two of which predominate in and characterize practically all petroleums. One of these series, called the methanes or paraffins, predominates in certain petroleums known as the paraffin-base oils. This is a stable series of compounds of the general chemical formula $C_nH_{2n}+_2$. The members as arranged in ascending values of n show a regular increasing specific gravity and temperature of boiling point. As an illustration of this series:

Methane CH_4 is a gas at ordinary temperatures and pressures.

Nonane C_9H_{20} is a liquid down to 59°F. (51°C.) and has a boiling point of 300°F. (150°C.).

Nonadecane $C_{19}H_{40}$ is a solid at 89°F. (32°C.) and boils at 626°F. (332°C.).

Another series known as the olefines are characterized by the general chemical formula C_nH_{2n} and predominate in those petroleums known as the asphalt-base oils. Members of other series are also present, but in small quantities; therefore, we need concern ourselves with but the two series above mentioned. The members of both series are hydrocarbons and have similar structure and characteristics. Each member has its own specific gravity and boiling point different from those of any other in the same series. However, a member in another series may have either the same boiling point or the same specific gravity, but both specific gravity and boiling point will not be the same.

The most important practical distinction between distillates obtained from different oils is that the distillates derived from the asphalt-base oils at the same boiling point are heavier than those derived from the paraffin-base oils.

2. Refining of Petroleum

In refining petroleum the first step is to separate it by distillation into a series of cuts. In distillation, the compounds of low boiling point and light gravity pass over first and the heavier compounds pass over at a higher temperature. When the average gravity of the distillate reaches a certain fixed value, the distillation is cut over into another tank and another series of compounds is obtained of higher gravity, until the average gravity of this distillate reaches the next limit. In this way the crude oil is separated into the following cuts or fractions:

1. Benzine. All distillates of a gravity down to and including 53° Beaumé.
2. Burning oils. Those distillates of gravity between 52 and 38° inclusive.
3. Fuel oils. Distillates between 37 and 25° inclusive.
4. Residuum. The remainder of the petroleum either liquid or solid.

The gravity limits of the various fractions given above are more or less indefinite and vary among different manufacturers, but these divisions are the ones generally adopted. Those who have followed the development of the industry in the past few years have noted that the tendency has been toward gradually lowering these limits, particularly those of the benzine group.

After the first fractioning, as above, the benzine is put into a second or steam still and subjected to another distillation during which it is separated into gasolines and naphthas of gravity according to the demands of the trade, or the standards of the particular manufacturer. It will be seen from the method described above that any gasoline may embrace a number of compounds of different densities, and the hydrometer tells only the average density of the composition. A mixture of a certain gravity may be obtained either by straight distillation, as described above, or by blending very light distillates and heavy distillates in the proper proportions. While the gravity can be varied by proper blending, the boiling points of the components are unchangeable and by redistillation a blend can always be separated into its original com-

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ponents. In other words, an examination by redistillation makes it possible to accurately determine the composition of any gasoline or naphtha.

3. Utilization

In general, internal combustion engines utilize light distillates by means of an apparatus variously called a carburetor, vaporizer, or mixing valve. The action in this apparatus consists in breaking up the fuel into minute particles and thoroughly mixing it

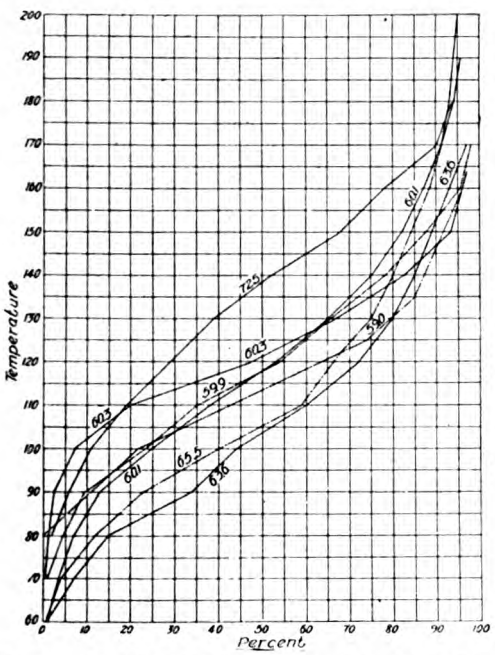

Fig. 1. Curves of fractional distillation of gasolines of various specific gravities and widely differing fuel values.

with air: for the best results the fuel should be so broken up as to be practically a vapor. The more volatile the fuel, the more easily it can be broken up and mixed with air. The nearer the boiling point of a compound is to its working temperature, the greater its volatility. Hence of any mixture the fractions of low boiling points are most easily volatilized and a knowledge of the boiling points of the various fractions are necessary to a knowledge of the behavior of the fuel as a whole. All of the fuel need not be of low boiling point, that is, easily vaporized; but there must be a sufficient percentage in order that starting will be assured. The remainder of the fuel must, however, be sufficiently volatile to be easily broken into a fog, or mist, and drawn into the cylinder without undue precipitation.

From the above consideration of practical conditions governing the burning of gasoline and naphtha, it can be seen that a knowledge of the boiling points is of much greater value in comparing relative suitability than knowledge of the gravity; and even if the gravity were desired, we can get only the average gravity of the entire mixture. It is, therefore, recommended that these light distillates be specified and purchased by the boiling point method. By this method the purchaser specifies the characteristics of the fuel as determined by a fractional distillation test. Such a test consists in placing a certain quantity of liquid in a flask, vaporizing it, condensing the vapor and catching it in a graduate. The percentages of the original volume obtained at the various temperatures may then be plotted on curves as shown in Fig. 1 and Fig. 2, which are characteristic curves of gasolines. If all conditions of petroleum composition and refining were the same the world over, gravity would then be a satisfactory means of comparison, for all curves would be of the same shape and parallel to each other as shown in Fig. 2, each curve representing a different gravity. Such, however, is not always the case, the true state of affairs frequently being as shown in Fig. 1. By the gravity method one would naturally expect a 72.5°B. gasoline to give better results than one of 63.6°B., but in reality this particular 63.6°B. gasoline is much the better, as can be readily seen from the curves. This is contrary to the usual understanding and clearly indicates the fallacy of the gravity method of grading.

4. Specifications and Purchase

The problem of fuel for motor cars is amenable to the same solution as that of coal for steam boilers. By test the most suitable fuel must be determined, then the characteristics of this fuel definitely specified and competitive bids invited on fuel to meet the specifications.

The specifications based on fractional distillation should give initial boiling point, that is, the point at which the liquid starts to vaporize, the final boiling point at which all liquid has disappeared from the flask, and possibly two or three points in between, and the percentage of the quantity which

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should boil over at these temperatures. The initial boiling point should be the maximum temperature which will insure easy starting. Final boiling point should be set as high as possible so as to produce a fuel which will not burn too rapidly; in fact, all points should be as high as practical, as high boiling points mean low prices. Fuel should, of course, be free from water and other impurities.

When the specifications of distillates are being prepared, it is well to consider the design of the engine and the purpose for which it is to be used. For instance, the ordinary automobile engine, usually of high piston speed, working under varying loads, needs a distillate having a narrow range of boiling points, that is, quick burning fuel. Heavy duty engines of slow piston speed and fairly constant loads operate better with fuels having the initial and final boiling points a considerable distance apart, as the slow burning fuel develops a higher mean effective pressure. Automobile engines are also subject to another condition. Being required to start easily in cold weather, they must use a fuel having a larger percentage of components boiling at low temperatures than engines that are installed in buildings kept at a reasonable degree of warmth.

The following specifications for liquid fuels will be found satisfactory for use on gas-electric cars.

a. Fuel shall be an unrefined petroleum distillate free from refuse, water, sand, etc.

b. The initial boiling point shall not be in excess of 185°F. (85°C.).

c. Dry point shall not be in excess of 550°F. (228°C.).

d. The first 10% should distill at a temperature not in excess of 230°F. (110°C.).

e. 60% should distill at a temperature not exceeding 374°F. (190°C.).

f. Not less than 95% of the liquid should be recovered from the distillation.

g. The above figures are based on the Engler process; if other methods of distillation are used results must be corrected to equivalent values.

For engines requiring quick acceleration and widely varying loads, a fuel having a narrow range of boiling point is desired. For these conditions the following specifications are recommended:

A. Fuel shall be free from impurities.

B. The initial boiling point shall not be in excess of 185°F. (85°C.)

C. Dry point shall not be in excess of 356°F. (180°C.). (Dry point will be indicated by a small puff of white vapor from residue in flask.)

D. The fractional distillation proceeding at the rate of one drop per second should be recorded in 10% cuts.

E. The first 10% should distill at a temperature not in excess of 230°F. (110°C.).

F. 50% should distill at a temperature not exceeding 270°F. (132°C.).

G. Not less than 97½% of the liquid should be recovered from the distillation.

Those who have been interested in the purchase of coal to specifications will immediately note that there is no mention, whatever, of heat value in the above specifications. The reason for this apparent omission is as follows:

All petroleum and petroleum products have practically the same heat value, that is,

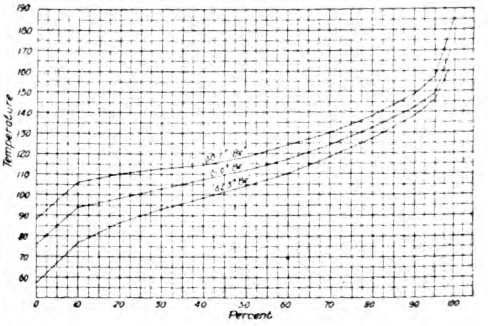

FIG. 2. CURVES OF FRACTIONAL DISTILLATION OF GASOLINES THE VALUE OF WHICH AS A FUEL IS PROPORTIONAL TO THEIR HYDROMETER READINGS.

19,000 to 21,000 B.t.u. per pound, and as there is, at present, no suitable distillate commercially practical, the heat value of petroleum products can be safely assumed.

5. POSSIBILITIES OF OTHER LIQUID FUELS

At the present time there is widespread demand for a cheaper and more efficient fuel than the gasoline and naphtha discussed above. The demand seems to have been met by a type of internal combustion engine utilizing heavy oils, generally known as the Diesel or high-compression oil engine. Much has been claimed for this apparatus, and the claims have been well substantiated in stationary and marine service, but as yet no engine of this type has been developed that is available for motor car service.

Any article considering liquid fuels for

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internal combustion engines would be manifestly incomplete without a word in regard to alcohol and coal distillates, more generally known as benzol.

Generally speaking, alcohol, either wood, grain or denatured, is a fuel even better than gasoline, and undoubtedly will figure more prominently in the future than it has in the past. Its advantages lie in the fact that it can be obtained from any vegetable matter and is, therefore, available in nearly all parts of the world.

The apparatus required is simple, inexpensive, and the cost of production small. Chemically, alcohol is a much more simple substance than gasoline and will be found more uniform.

The only reason that prevents its use is the price, and perhaps certain government restrictions in regard to inspection, bonding, and storing. Constant search is being carried on for a vegetable which will yield large quantities of alcohol at minimum cost. In Cuba, sugar cane refuse will furnish alcohol that may be sold at 12 to 15c. per gallon.

When the problem of production has been satisfactorily worked out, alcohol with even a lesser heat value than gasoline, that is, 14,000 B.t.u., will be a competitor on the fuel market.

In Europe there is a gasoline substitute called benzol which is meeting with considerable success. This fuel is produced by the destructive distillation of coal. In the matter of advantages and disadvantages it ranks between unrestricted alcohol and gasoline. Like alcohol, it is a mixture simple and uniform. Like gasoline, it has a high heat value ranging from 18,000 to 19,000 B.t.u. It is heavier than gasoline and, therefore, more work is obtained per gallon.

The price of benzol is against its use, however, for unless gasoline be over 25c. per gallon, the cost of production of benzol from coal at $1.75 per ton, even with the revenue derived from the other products of distillation, will prohibit its use. It seems probable that with our enormous coal deposits there will be developed a means for producing benzol more economically.

Lubrication

The successful lubrication of internal combustion engines has in the past been considered a difficult proposition and one surrounded by more or less mystery, the difficulty being to obtain an oil that will work under the little known conditions that exist in the combustion chamber.

The prevailing idea of a gas-engine oil was that it should have a high flash and fire test, supposedly in order to withstand the high temperature of the combustion chamber. The flash and fire test temperatures have usually been between 400 and 500°F., but it is manifestly impossible to expect that an oil of this test will not burn in a temperature variously estimated to be between 1800 and 2500°F. Whatever have been the troubles with internal combustion engine lubrication in the past, the problem is now satisfactorily solved and much is known as to the lubrication conditions of the cylinder, and oils for this purpose can be and are prepared which produce entirely successful results.

The idea of lubrication is the same with all pieces of apparatus, that is, to successfully lubricate at minimum expense. To lubricate is of prime importance. The matter of economy should be secondary. As the first feature must be obtained, we will therefore assume successful lubricating oils. To attain economy, we must have an oil of which little is used, or which wears well. Therefore, the aim should be to prevent excess oil getting to the combustion chamber, thereby using as little as possible, and second, to obtain a clean burning oil, that is, one which upon burning leaves as little carbon as possible.

The quantity of oil passing by the piston rings to the combustion chamber is governed by the viscosity of the oil and the construction of the engine and its lubricating system. A gravity feed inherently permits the quantity of oil consumed to be accurately controlled. As the storage for this oil is usually set away from the engine and kept at low temperatures, a much different oil is required than with either the force feed or splash lubrication system. As the storage for oil in the latter system is generally the lower portion of the crank case, all oil is speedily warmed to a rather high temperature, with a consequent loss of viscosity. As in different makes of engines there are differences in piston fit, number, and size of rings, and heating of the oils, different viscosities are naturally needed for best results. The question of the most suitable viscosity is one to be settled by each manufacturer, although the personal equation of the operator has great bearing on the success obtained from the use of any oil.

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A clean-burning oil must primarily be free from dirt and sediment, but aside from this there will be a certain amount of carbon deposit from the combustion. The amount of this deposit is usually determined by the carbon residue test, which consists in vaporizing and burning a certain amount of oil and measuring the percentage of carbon residue remaining after all liquid has disappeared. All carbon deposit is not, however, due to excess or poor quality of oil. Excess of fuel or dirty fuel may cause much more carbon than it is possible to obtain from the lubricating oil.

The importance of high-flash and fire tests have been greatly over-estimated. However, the oil should test sufficiently high to prevent undue loss by vaporization from the hot wall of the cylinder and piston. Engines which are subject to cold weather use should have an oil of low cold test, otherwise when the engine is first started the oil may be so stiff as not to splash or flow, and the engine be without lubrication for a considerable period. In general, it may be said that any good gas engine oil from a reputable manufacturer can be used successfully, although, depending on the conditions of operation and construction of the engine, certain oils can be used with a greater degree of satisfaction than others.

Thus far no specifications or laboratory tests of oil have been found that are satisfactory for general use. The practical workout test is by far the best means of determining the merits of a lubricating oil. When purchasing an oil its first cost should not be given undue importance. The cost of motor car operations is figured on a car mile basis, and the life of an oil—that is to say, the number of car miles per gallon or the cost per car mile—must be regarded as the only final criterion of the value of an oil.

Examination of Natural Gas for the Production of Gasoline *

By E. S. MERRIAM and J. A. BIRCHBY.

THE production of natural gas gasoline from the casing-head gas of the oilfields, by compression and cooling, has, within the last five years grown to be a very important industry. Through the failure of many plants to obtain gasoline in paying quantities, it was early recognized that a preliminary examination of any proposed gas should always be made, and naturally the problem was put up to the analytical chemist. Anyone at all familiar with the literature on natural gas will realize that positive statements in regard to the presence and quantities of the higher paraffins occurring in natural gas are not numerous. Ethane, propane, and butane were early found in natural gas, but no reliable figures could be given as to their amounts. In fact, from combustion data alone only the total quantity of paraffin vapors present can be determined, and not which ones.[1] Generally, the results are recorded on the assumption that methane and ethane alone are present.

The exact analysis of a mixture of five hydrocarbon gases does not seem possible, with the means available in an ordinary laboratory. Fractional distillation at –190°C. and –120°C. seems to have given Lebeau and Damiens[2] good results. The use of high pressures in connection with the critical temperature of the vapors believed to be present might lead to a more or less correct result, though the solubility of a gas in a liquid hydrocarbon must be taken into account.

Even if we had methods whereby the percentage of butanes and pentanes could be determined in a given gas, it would still be a difficult matter to calculate how much of each could be condensed to liquid at any given temperature and pressure, and when it is found that the various makes of compressors and condensers are not equally efficient, it can readily be seen that the chemist should be extremely conservative and cautious in his reports.

*Abstract from *Jour. Ind. & Eng. Chem.*, October 1913.

[1]Burrell, G. A., Bureau of Mines *Bulletin* No. 15, p. 67.

[2]*Compt. rend.*, Vol. 156, pp. 144-7 and 325-7; *Chem. Abstracts*, Vol. 7, p. 1338.

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In view of these facts, it is evident that the most logical method to pursue is to obtain gases from plants where the production is known, and to examine these gases by methods which will respond to the presence of the more readily condensible hydrocarbons. In this way empirical relations between certain physical and chemical properties of the gases and the yields in actual practice can be established, and a probable yield for any unknown gas can be predicted.

A second method is to construct a small compressor so that any gas may be subjected to any desired pressure or any degree of cooling. We have proceeded along both these lines, and the object of this article is to describe the methods which we have found most suitable.

It may be of interest to describe first some methods which we tried and discarded.

First—By passing the gas through absolute alcohol it was believed that the heavier hydrocarbons would be partly dissolved. If this alcohol be then diluted with water, the hydrocarbons, being insoluble in and lighter than water, would separate, and their volume could be determined. This method was used by Bunsen in showing the presence of benzine in illuminating gas (Hempel-Dennis, 'Gas Analysis'). In the case of natural gas, however, owing to the rapid escape of the lighter constituents, such a brisk effervescence occurred on diluting that the heavier hydrocarbons were carried off. Even with ice water and in a closed vessel, no reliable results could be obtained.

Second—By treating the gas with a suitable high boiling oil, such as lubricating oil, to absorb the vapors, and then distilling the mixture, it was sought to regain the vapors. The hydrocarbons thus obtained could not be condensed satisfactorily.

Third—By combustion. This method, as mentioned above, gives the total paraffins only, and while a rich gas can easily be distinguished from a poor one, the method did not seem to respond with sufficient delicacy to the presence of the heavier hydrocarbons.

The first method which showed promise was to determine the solubility of the gas in absolute alcohol.[3] The following solubilities are given in Watt's dictionary:

1 volume of alcohol dissolves:
- 0.523 vol. CH_4 at 0°C.
- 1.500 vol. C_2H_6.
- 6.000 vol. C_3H_8.
- 18.000 vol. C_4H_{10}.

TABLE I

No	D	Per cent air	D'	A	B	A/B	Olive oil absorption	M	YIELD	PRESSURE	REMARKS
26	1.305	25.0	1.406	13.6	6.0	2.27	15.8	67	5.0	80	"Gas pump gas"
27	1.276	38.5	1.383	11.1	5.4	2.06	13.2	66	5.0	90	"Gas pump gas"
30	1.41	0.0	..	19.0	6.8	2.79	26.2	65	8.0	80	"Gas pump gas"
33a	1.24	44.0	1.429	11.2	5.7	1.97	14.5	60	5.0	80	"Gas pump gas"
33b	1.12		..	6.6	1.9	3.48	9.2	58	.	....	33a after compression
77	1.244	0.0	..	12.9	4.3	3.0	19.0	58	4.0	....	Taken from well under 50 lbs. pressure
80	1.202	61.0	1.515	6.8	3.2	2.12	8.8	69		....	Yield 6 to 7 after eliminating air at 225 lbs.
84	1.004	34.0	1.005	2.4	1.1	2.18	5.2	73	0.75	100	
85	0.931	27.5	0.905	3.7	0.4	9.2	4.7	48	0.0	250	This gas had been through a plant at 250 lbs.
96	0.799	0.0		4.0	1.1	3.63	5.8	58	0.50	250	Unsuccessful plant
99	0.795	0.0		3.4	1.1	3.1	4.7	69	0.25	200	Unsuccessful plant
117	1.087	0.0	.	6.9	1.4	4.92	10.6	52	0.0	180	Gas had been through at 180 lbs.
125	1.398	26.5	1.542	16.0	7.1	2.25	21.4	60	5.0	110	
135	1.31	0.0	..	14.0	4.4	3.18	16.8	57.5	4.0	not known	
136	1.142	17.0	1.171	8.8	2.9	3.04	9.0	61	2.5		

The process used was simply that of Hempel for determining benzine vapors in illuminating gas: 1 c.c. of absolute alcohol was placed in a Hempel explosion pipette over mercury, 100 c.c. of gas introduced, and the decrease in volume noted after three minutes shaking. This decrease will be due to a slight extent to methane, and in an increasingly greater measure to ethane, propane, etc. The 1 c.c. of alcohol will be completely saturated with CH_4, probably nearly saturated with C_2H_6, but will in general not be saturated with the heavier constituents which are present in smaller amounts and which have a far higher solubility. If, then, a second quantity of 100 c.c. of fresh gas is shaken with this same 1 c.c. of alcohol, the decrease in volume this time will be due mainly to the heavier vapors present. Since alcohol has an appreciable vapor tension, is also an oxygen-containing body, and should therefore be a poorer solvent for hydrocarbons than another hydrocarbon, we soon discarded its use and used 1 c.c. of kerosene instead. The results obtained by the use of kerosene have

[3] Burrell, G. A., *loc. cit.*

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proved both successful and of great value.

In Table I, the figures under A denote the number of cubic centimetres of gas absorbed by 1 c.c. of kerosene; under B, the absorption when a second 100 c.c. of gas is shaken with the same 1 c.c. of kerosene. B is, of course, in every case, smaller than A, and is proportional to the heavier constituents present. We have found that the value of B approximately represents the yield of gasoline in gallons per 1000 cu. ft. of gas. When B. is small, it will exceed the yield; when high, it will fall below the yield. The ratio of A to B is also of significance, as can be expected from general principles. If the hydrocarbons causing B are of high molecular weight, they should be more readily condensible and show a higher solubility. The first 100 c.c. of gas, therefore, will not come so near to saturating the 1 c.c. of kerosene, and B will be greater than would be the case if more volatile constituents were present. The ratio of A to B should show something about the condensibility of the vapors and the pressure needed to liquefy them. The determination of A and B should, of course, be made at a fixed temperature; the figures given refer to 20°C.

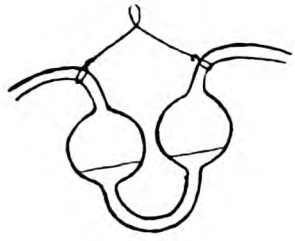

FIG. 1.

Further information in regard to the nature of the hydrocarbons can be gained very simply. It is easy to determine the mean molecular weight of the vapors which have dissolved in any solvent. All we need to know is their volume and weight under the temperature and pressure prevailing. For this determination we have used a small vessel of the shape shown in Fig. 1. This contains some glass beads to increase the surface, and is charged with 5 c.c. of olive oil. We have used olive oil rather than a mineral oil since it has practically an unvarying constitution, is non-volatile, and does not foam. The olive oil is first saturated with our city gas, which from combustion data appears to consist of about 75% methane and 25% ethane; the gas in the upper part of the bulbs is driven out by aspirating through a small amount of air, and the whole is weighed. The bulbs are then connected between a gas burette and Hempel pipette filled with water, and 100 c.c. of gas is slowly passed back and forth a dozen times or more, or until no further gas is absorbed. The decrease in volume and the increase in weight of the absorption bulbs are noted. Readings of the

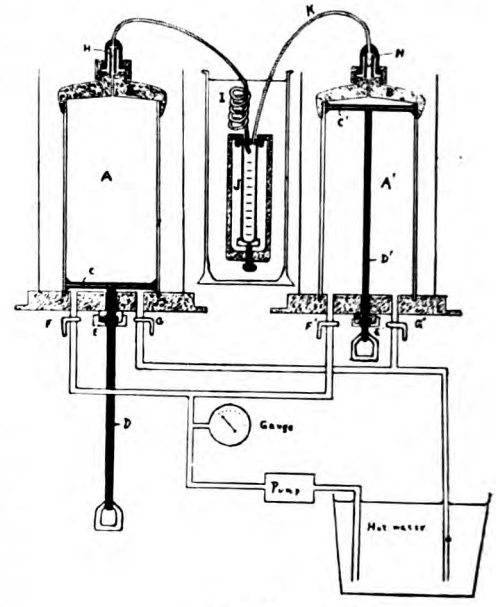

FIG. 2.

temperature (which we have always kept as near 20°C. as possible) and pressure then give all the necessary data for computing the molecular weight of that part of the vapor which has dissolved in the oil.

An example will make the method of calculation clear. In gas No. 26 of Table I, 15.8 c.c. of gas was dissolved by the olive oil, and the oil thereby gained in weight 42.9 mg. The temperature was 20°C., and the barometric pressure (corrected for the vapor tension of water) was 740 mm. At 0° and 760 mm. the 15.8 c.c. reduces to 14.32 c.c. The weight in milligrams of 22.4 c.c. of any gas measured at 0° and 760 mm. is equal to the molecular weight M. Therefore, $14.32 : 42.9 = 22.4 : M$. M is 67 in this case. The molecular weight of butane C_4H_{10} is 58, and of pentane C_5H_{12} is 72. It seems certain, therefore, that this gas contains at least 15.8% of condensible hydrocarbons cor-

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responding to butane and pentane. The absorption is, of course, by no means quantitative. It will vary, for one thing, with the amount of olive oil used. Using mixtures of air and gasoline vapors of known composition, we have found it possible, using 5 c.c. of oil, to recover from 40 to 60% of the vapor present, according to the volatility of the gasoline used in preparing the mixture.

In any case, the figure thus obtained for the molecular weight of the condensible vapor is of value. From it we can draw conclusions as to the pressure needed and as to the quality of the gasoline obtainable. A low molecular weight would mean a very lively condensate; a high figure would indicate a less volatile gasoline. As a rule, the ratio of A to B is also consistent with the molecular-weight determination, a high M going with a low ratio. The determination of M also enables one to tell whether a gas has been subjected to pressure.

These few simple determinations together with the density of the gas and determination of the air present, when checked upon gases where the production is known, enable one to draw a fair conclusion as to the probable yield of any gas.

In Table I are given the results of examination of gases from a number of plants. D gives the density of the gas, taking air as unity. When air is present, the density of the gas itself, D′, can be calculated from the formula:

$$D' = \frac{100\,D - \%\ \text{air}}{100 - \%\ \text{air}}$$

Under 'Yield' is given the number of gallons of gasoline which the operators claim to be making per 1000 cu. ft. of gas. No. 26, 27, 30, and 33*a* are all 'gas pump gas,' that is, are obtained from the wells by use of a vacuum. This process favors the evaporation of the lighter constituents from the oil, and usually gives a rich gas requiring only moderate pressures; 33*b* is the same gas as 33*a* after it has been through the plant at 80 lb. pressure. The change in the figures for A and B and their ratio is quite marked. No. 84 is from a plant which is barely making expenses. No. 85 is gas which has been through a plant at 250 lb. pressure. M is extremely low and A/B very high. No. 117 is gas which has been through at 180 lb. No. 96 and 99 are from unsuccessful plants. No. 80 was examined by us and we reported a probable yield of 2½ gal., but stated that if the entrance of air could be avoided, a yield of 6 gal. might be expected. The operator went over his lines, finding numerous leaks, which he repaired, and is now making 6 to 7 gal. per 1000 cubic feet.

For further tests, we have constructed a small compressor by which the exact yield under any working conditions can be obtained. The results obtained in this way are free from any uncertainty, and the approximations of the analytical methods and personal equation of the analyst are done away with.

In the accompanying Fig. 2, A and A′ are two cylinders of polished brass tubing, 4 by 10 in., each fitted with a bronze cap, B, B′, screwed and soldered on. Each cylinder is provided with a piston, C, C′, with close-fitting leather cups above and below, and a piston rod, D, D′, provided with a stuffing-box, E, E′. Each cylinder is provided with a water-jacket which can be filled with hot water. In the base of the cylinders are two openings, F, F′, and G, G′, which serve for

TABLE II

No	D	Per cent air	D′	A	B	A B	Olive oil absorption	M	Empirical formula from combustion data	Calculated D	Yield	Pressure Lbs.	Cooling temperature
145	0.94	0.0		7.3	2.5	2.92	8.8	69.0	$C_{1.00}H_{2.35}$	0.88	1.35	100	7° C.
											2.26	200	
											2.94	250	
146	1.062	7.0	1.068	8.5	3.2	2.66	10.4	63.5	$C_{1.00}H_{2.30}$	1.045	1.49	100	8° C.
											2.76	200	
											3.58	300	
147	0.957	0.0		6.6	2.3	2.87	7.9	68.0	$C_{1.00}H_{2.30}$	0.947	1.33	100	7° C.
											2.14	200	
											3.00	300	
148	0.802	0.0		3.6	0.7	5.15	4.2	105?	$C_{1.00}H_{2.30}$	0.803	0.36	100	15° C.
											0.64	200	
											0.91	300	
149	0.958	0.0		5.9	2.2	2.68	6.5	76.0	$C_{1.00}H_{2.35}$	0.955	1.43	100	8° C.
											2.45	250	
											3.12	350	
161	0.886	0.0		5.8	1.6	3.62	6.9	69.0	...		0.79	100	15° C.
											0.99	150	
											1.26	200	
											1.52	300	

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the entrance and exit of the hot water used for exerting the pressure. By the use of a small boiler testing pump, any pressure up to 500 lb. can be exerted on the gas, and the pressure can be controlled accurately by the gauge which is placed between the pump and cylinders. A nut and sleeve press the small glass tube, H, H′, into a gas-tight connection on the cap of each cylinder. The sleeve is partly cut away so that the glass tube can be observed. From cylinder A leads a small capillary copper tube, the lower part of which is wound spirally and serves as the condenser I. This passes through a small brass disk against which is pressed a graduated glass tube J, which serves to collect the condensed liquid. This glass tube is seated tightly with a rubber washer, as are also the tubes H and H′. Through this brass disk passes another tube, K, which conducts the spent gas to the other cylinder. The tube J and condenser I are set in a jar of water of any desired temperature.

The method of operation is as follows: The graduated glass tube J is removed and a little water is drawn into the cylinders on top of the pistons; the pistons are then forced up to the top of the cylinders. The excess water is thus forced out and only enough remains to fill the space between the pistons and caps of the cylinders. Connection is now made with the gas to be tested. By opening the valves G and G′, and pressing on the stirrups, the pistons are drawn down, and the cylinders filled with a measured volume of gas. The graduated glass tube J is now attached, and it and the condenser I are surrounded by the cooling water. Boiling water is placed in the jackets, the valves G and G′ closed, and hot water is pumped into cylinder A′ through F′, forcing the piston up and driving the gas over into A. The rise of the water into the tube H′ shows when the gas is all out. The valve F′ is now closed. All the gas is now in A. The valve G is closed and hot water is pumped into A, compressing the gas.

The gauge shows the pressure. When the desired pressure is obtained, the valve G′ is opened very carefully, allowing the right-hand piston to descend. The pump is now operated and the pressure kept constant. The gas thus passes slowly at the desired pressure through the condenser at the desired temperature, and any liquid forming in the condenser is carried down and collects in the glass tube which is graduated so as to read directly in gallons per 1000 cu. ft. of gas.

The spent gas passes over into cylinder A′. After the gas has passed through at any pressure, it can be transferred back by opening G and pumping in at F′, and put through again at a higher pressure. As many readings can be made as desired. The use of hot water in the jackets and pump prevents the condensation of gasoline in the cylinders, though it is always advisable, especially in the case of rich gases, to increase the pressure by easy stages. If the pressure were raised to 200 lb. at the start some liquid might condense in the cylinders and not get over into the measuring tube.

We have found that all the gasoline obtainable at any pressure is thrown down by one operation, a second trip through at the same pressure not yielding any more liquid.

We have found this apparatus to work well, and have examined a good many samples of gas by the absorption methods and the compression method.

The results of a few of these tests are given in Table II. Under 'Yield' is given the quantity of liquid condensed by use of the compressor described above. This figure is to be looked upon as an upper limit. The yield on the large scale will be less than the figure given, owing to leakage, evaporation losses, imperfect cooling, etc. The combustions were made over mercury, using oxygen and a heated platinum spiral. In almost every case the figure for hydrogen is slightly greater than that corresponding to a paraffin of the formula $C_nH_{2n}+_2$. This is undoubtedly due to experimental error, as it is well established that natural gas does not contain free hydrogen. The density of the gas calculated from the empirical formula agrees fairly well with the observed D.

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Bituminous Concrete Pavements*

By WM. B. SPENCER

Up to the time of the advent of the automobile, the question of modern highways was pretty well solved, except for heavy city traffic, by the discoveries of John Macadam, and the more recent improvements of the French engineers and the pioneers of this country. But in their system of road building the pioneers did not contemplate heavy vehicles carrying loads of from 1000 to 20,000 lb. and passing over their prepared roadbed at the rate of from 5 to 50 miles per hour, sucking up the carefully placed filler or binder, and depositing it over our lawns, our farms, and in our nouses, permeating the entire atmosphere with a dust which was both objectionable and unhealthy. In the West, temporary relief was found by taking the crude natural asphaltic or semi-asphaltic oils of California, Texas, and Kansas and sprinkling them over the macadam roadways. This generally gave temporary relief from the dust nuisance, but it was found that these oils, which had not gone through the process of refining, contained many substances which were detrimental to the automobile tire. It was also found that they had decidedly bad effect on the binding materials of the macadam roadways. A well bound macadam roadway secures its cohesiveness by the hydration of its granular constituents, but when the surface coat is more or less thoroughly sealed by the application of a heavy oil, then the body of the mass is denied the water which prolongs its life, and shortly thereafter the road will commence to ravel.

Some time during the year 1903 an observer in the oil regions of California noted that a flock of sheep, which had been driven back and forth to pasture, over an oil saturated piece of ground, gradually consolidated this soil to such a degree of hardness that it was not affected by vehicular traffic, and also produced a highway which was cheap and did not require the use of stone, which had always been deemed necessary for the construction of highways. A tamping roller, made as nearly as was mechanically possible to imitate the sheep's foot action on the soil, was designed, and the petrolithic or tamped road was launched. In some sections of California it met with fair success, and is still in limited use in that section of the country.

In the summer of 1907 a road of the same type of construction was laid near New York City, and during the summer and fall season of that year it withstood traffic conditions remarkably well, but during the early winter frost penetrated the road and immediately thereafter a warm rainy period ensued, with the result that the road rapidly disintegrated and became a quagmire. The following spring it was found necessary to entirely remove the prepared roadway and substitute another form of road construction.

The petrolithic specifications were substantially as follows: The earth roadway to be improved shall first be cleared of all vegetable and other foreign materials, and shall then be crowned with a road grader, or by hand, to the proper line and grade, filling in all low places with suitable material. It shall then be plowed to a depth of not less than 8 in., after which a disc harrow shall be run over the surface of the plowed roadway in order that all lumpy material shall be disintegrated. The road shall then be carefully graded to the required cross-section, after which there shall be distributed one gallon of hot asphaltic oil to the square yard of pavement. The sheep's foot or tamping roller shall then be used until its teeth refuse to penetrate into the soil for a distance of more than one inch. The material shall then again be lightly harrowed and an application of hot asphaltic oil, at the rate of not more than one-half gallon to the square yard, shall be applied, and the surface shall then be lightly harrowed, after which the tamping roller shall be again used until the teeth refuse to penetrate. The surface shall then be covered with a coating of stone chips or sand and rolled with light circular roller.

Other experiments with the same or allied processes were made in the East dur-

*Abstract from *Jour.* Amer. Soc. Eng. Con., June 1913.

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ing the ensuing year with no better results, and in so far as this type of construction is concerned, I believe that it has been virtually abandoned outside of California.

Various states and municipalities then attempted to improve on the water-bound macadam and its filler of stone chips by substituting heavy asphaltic or semi-asphaltic oil, by means of what is termed the penetration or grouting method. The initial process relating to the preparation of the base and first course of stone was substantially the same as in the preparation of the water bound type of macadam. The second course, generally composed of what is known as 1½-in. stone, was then spread upon the base course and rolled with a 10-ton roller to an average thickness of about 4 in. An application of asphaltic oil, heated to a temperature of approximately 300°F., was applied, at the rate of 1½ gal. per square yard, by means of pouring pots or sprinkling wagons and immediately thereafter a coating of stone chips was applied, and the surface was then again carefully rolled with a steam roller. Immediately after this rolling another application of hot oil was made at the rate of approximately ½ gal. to the square yard and another course of stone chips applied, after which the surface was again rolled, and after a short period of time, ranging from three to twenty-four hours, the road was opened to traffic.

The success of this type of pavement is problematical, and has been abandoned in many places. The states of New York and New Jersey spent many millions of dollars on this type of road construction during the seasons of 1910-1911, but during the season of 1912 the use of this type of construction was almost entirely abandoned. In order to make a success of this type of construction, it has been found necessary to have almost ideal climatic conditions. A working temperature of over 55°F. has been found necessary, because in a lower temperature the stone becomes so cold that it immediately chills the asphaltum when applied and prevents it from thoroughly penetrating the voids in the mass; an unstable top surface coat is thus formed with an under stratum which is poorly consolidated. Traffic soon finds the weak spots in this pavement, with the results that raveling soon begins and the complete disintegration of the pavement is only a matter of a short time. In order to secure even fair results from penetration work, I have found the following conditions to be absolutely necessary:

First, an asphaltic oil of approximately 18°B. gravity at 77°F.; a flash point of not less than 400°F.; a fixed carbon total of not more than 6%; a bitumen content of not less than 99%; and a paraffin scale residue of not more than 3%. This material should be heated and applied at a temperature of not less than 300 or more than 350°F. The temperature of the air should not be less than 60°F. The mineral aggregate should be 'bone' dry and the asphaltic oil should be applied to the surface by means of sprinkling appliances containing an exact quantity of the material; templates or other means of determining the exact quantity of oil to be applied per square yard of roadway should be laid on the prepared road surface, in order that an even distribution of the oil may be secured.

Power sprinkling devices employing compressed air as an atomizer have been used with fair results, but the continued decrease of this method of construction in favor of some method of the mechanical mixing of the cementing medium and the mineral aggregate, is proof evident that at its best the penetration system is only a step in the right direction from the water bound macadam era to the present era of mixed bituminous surfaces.

Bituminous Macadam

This type of pavement has been adopted by some of the state highway departments for use on main traveled highways and also on the principal streets of some smaller towns. I submit herewith a specification of this type of pavement as prepared by the State Highway Department of Pennsylvania.

"After completion of the bottom course, telford or macadam, the bituminous macadam course is to be placed thereon. It shall consist of a mixture of bituminous material and good hard stone acceptable to the State Highway Department, trap rock preferred. When trap rock is used the stone shall be of such size as will pass through a 2-in. ring and be rejected by a ½-in. ring, and shall be entirely free from dust. When limestone is used it shall be of such size as shall pass through a 3-in. ring and be rejected by a 1-in. ring. When asphalt is used it shall contain not less than 90% bitu-

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men and shall be heated to a temperature of 350 to 400°F. When tar is used it shall be heated to a temperature of 270 to 325°F. The bituminous material shall be mixed with the stone in a mechanical mixer and then spread on the telford foundation to a depth of 5 in. in the centre for a width of 6 ft., and to a depth of 4 in. on the sides, loose measurements, and thoroughly rolled and compacted. One and one-half to two gallons of bituminous material per square yard of road surface will be required to make the mixture. The contractor shall, upon the direction of the engineer in charge, heat the stone to a temperature of 250 to 300°F. before mixing the compound. After the above-mentioned course has been thoroughly rolled in place and compacted with a 10-ton roller, to the satisfaction of the engineer or inspector in charge, and the surface swept clean, the surface shall be painted with the neat bituminous material, using ½ gal. per square yard of road surface, unless otherwise directed by the engineer. Immediately following the flush coat or painting, there shall be applied a coating of clean rock screenings, ¼ to ¾ in. diameter, of the same material as has been used in the 4-in. course, to a depth of ½ in., and rolled into the voids in the surface. Should the bituminous binder appear on the surface after rolling, enough additional rock screenings must be applied to take up the surplus material."

This type of construction is one which, to my mind, leaves considerable to be wished for. Personal experience has led me to believe that the grading of the mineral aggregate is not done with sufficient care to give a minimum of voids in the mass, with the result that, it is my opinion, depressions and raveling are apt to occur in a period of not more than three years after the pavement is laid.

Bituminous Concrete Topeka Specifications

The specifications covering this type of construction will not be given here in detail. In a general way, however, the court held that a grading of mineral particles ranging from material which passed a 200-mesh sieve to a maximum amount of from 5 to 11% to particles which passed in a 2-mesh sieve to a maximum amount of 10%, did not infringe on the patents of the Warren Bros. Co. This decision had a far-reaching effect, as it made possible for engineers to specify and contractors to bid on a graded bituminous bound pavement without conflicting with the patents of the Warren Bros. Company.

Where this pavement has been laid with care and by experienced contractors, it has met with extreme success, and is being specified in ever-increasing quantities in all parts of the country. During the season of 1912 the city of New York, borough of Queens, awarded contracts for the construction of over 1,500,000 sq. yd. of this type of pavement in the aforesaid borough. The highways on which this pavement is laid are the main arteries of travel leading to and from Greater New York points on Long Island. Over 80% of this travel consists of pleasure automobiles and heavy auto-trucks, and a majority of the remainder being heavy horse-drawn farm wagons. A traffic census taken on the Merrick road this summer showed an average of over 6000 vehicles per day, with a daily total of approximately 10,000 vehicles passing over it on Saturdays, Sundays, and holidays.

The pavements have been down for too short a time to be able to judge of their future wearing qualities, but the fact that they have gone through the past season with excellent results is, to my mind, evidence of the fact that they will bear the heavy traffic imposed upon them for many years to come without the necessity of any large amount of repairs. The old roadbed consisted, in the majority of cases, of old macadam which had been worn down to the base course of stones. This course was lightly scarified and sufficient 1½-in. stone was added to bring the road to the proper cross-section and crown, and 2 in. below the finished grade. A layer of screenings or sand was then applied and worked into the voids by means of hand brooms and puddling with water, and the whole foundation was then thoroughly rolled with a 10-ton macadam roller. The bituminous concrete was then laid and raked by expert rakers, and then thoroughly rolled with a 6-ton tandem roller until it had an ultimate thickness of 2 in. The pavement was then dusted with a coat of portland cement to fill any surface pores, and was opened to traffic after a period of not less than twelve hours.

In order that the shoulders of the roadway should be protected, a layer of three rows of vitrified block was butted in against each side of the roadway and the joints were then poured with an asphaltic filler. In the outlying sections the wings of the roadway

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were carefully graded and suitable gutters were constructed leading to masonry seeping basins. In sections where storm-water sewer systems prevailed, the gutters were paved with either cobble or brick, and the construction extended from curb to curb.

There is another type of pavement which has recently come into vogue in the Middle West, and is also being used in some parts of the East. It bears the trade name of 'Dolarway' pavement, but I understand that it is also being laid in various parts of the country without the use of the trade name. This process consists of first laying a concrete base of suitable thickness of rather a rich mixture and providing suitable expansion joints. Immediately after the laying of the concrete and before the initial set has taken place, the top of the concrete is carefully troweled, in order to have a uniform finish and to bring the finer particles to the surface, after which the surface is broomed. Upon this foundation there is spread a layer of hot bitumen at the rate of about one-third gallon to the square yard, immediately after which a uniform layer of clean dry sand or stone screenings is spread in a sufficient quantity to cover the asphalt coat and leave a wearing coat of not less than ¼ in. thick. This pavement is at the present time in its infancy, and it is therefore impossible to form an opinion as to its permanent quality. One good feature of this type of pavement, however, is the fact that, irrespective of the wear of the surface course, there always remains the concrete foundation which can be used either for a new application of this same type of surface treatment, or it can be used for another type of pavement.

Sheet Asphalt

This type of pavement has probably received more praise and at the same time more criticism than any other form of bituminous pavement, but in my opinion there is no more substantial bituminous pavement laid than modern sheet asphalt pavement. In the early days, and even in more recent times, paving engineers have given too little attention to the details which go to make up a good modern pavement of this type. This lack of attention to details is slowly being eliminated, due greatly to the fact that intelligent bodies of engineers and contractors have been working together to standardize the specifications covering this type of pavement. A set of standard specifications covering the making and laying of sheet asphalt, which is the result of many years' study and labor, has recently been published by the American Society of Municipal Improvement. A digest of these specifications may be of interest.

Refined Asphalts

The tests provide that all penetrations shall be made at 77°F., and are to be expressed in hundredths of a centimetre with a No. 2 needle acting for five seconds under a total weight of 100 gm. There is no distinction made between the so-called natural or lake asphalts and the oil asphalts; that is, those derived by distillation from asphaltic oils, it being stated that all asphalts shall be prepared from a natural mineral bitumen, either solid or liquid, or a combination thereof, by suitable and approved methods of refining.

"All shipments of refined asphalt shall be uniform in consistence, and shall not vary more than 15 points in penetration at 77°F. Of the total bitumen, 98½% shall be soluble in carbon tetrachloride."

Flux

The specifications covering the fluxes state in part that they shall be the residue obtained by the distillation of paraffin, asphaltic or semi-asphaltic petroleum, and shall be of such character that they will combine with the asphalt to be used to form an acceptable and approved asphalt cement.

Sand

The careful grading of the sand particles has received more study in recent years, with the result that the modern specifications are as follows:

Mesh.	Retained on, mesh.	Per cent.
200	...	0 to 5
100	200	10 to 25
80	100	6 to 20
50	80	15 to 40
40	50	10 to 30
30	40	8 to 25
20	30	5 to 15
10	20	2 to 10
8	10	0 to 5

Particular attention is called to the large percentage of particles which must pass the 80-mesh sieve and the small amount which pass a 20, 10, and 8-mesh sieve.

It is unusual to find a sand which can

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comply with both the fine and the coarse requirements of these specifications. I am at present engaged in the laying of a considerable amount of sheet asphalt pavement under these specifications in the city of Norfolk, Virginia, and it has been found necessary to secure two sands in order to produce a blend which meets the requirements of the specifications. The fine grain sand is secured in the Dismal swamp of North Carolina, and the coarse sand is secured by dredging in the Chesapeake bay. A blend of three parts of the Dismal swamp sand to one part of the dredged Chesapeake bay sand produces a mixture which complies in every respect to the requirements of the standard specifications.

The exact quantities of materials used in making one 9-cu. ft. box of our Norfolk paving mixture are as follows: Sand, 880 lb.; carbonate of lime, 170 lb.; and asphalt cement, 127 lb.; a total of 1177 pounds.

A 9-ft. box of this mixture lays approximately 5.28 sq. yd. of finished pavement 2 in. thick after compression with a steam roller weighing not less than 200 lb. per inch width of tread.

Binder Stone

The requirements are that the stone shall be clean, hard, and free from any particles that have been weathered and are soft. It shall all pass a 1¼-in. screen, and from 15 to 30% shall pass a 10-mesh screen. Particular attention is called to the latter requirement. Strict conformation with this phase of the specifications will produce a dense binder which will have much to do with the ultimate life of the pavement.

Asphalt Cement

The requirements of asphalt cement are that it shall be composed of refined asphalt or asphalt and flux prepared in the proper proportions, and melted in such a manner that they shall be blended into a homogeneous mixture complying with the following requirements:

(a) It shall be thoroughly homogeneous and shall not be oily to the touch.

(b) It shall have a penetration between 40 and 75 at 77°F., depending upon the sand and asphalt used and traffic upon the street on which the pavement is to be laid.

(c) It shall not flash below 300°F. when tested in a New York state closed oil-tester.

(d) When heated in an open tin at a temperature of 325°F. for five hours in a hot-air oven, it must not show a loss by volatilization of over 5%, and the penetration at 77°F. of the residue left after such heating must not be less than one-half of the penetration at 77°F. of the original sample before heating.

(e) When the pure bitumen of the asphalt cement is brought to a penetration of 77°F. of 50 and made into a briquette having a cross-section of 1 sq. cm., it shall have a ductility of not less than 20 cm. at 77°F., the two ends of the briquette to be pulled apart at the uniform rate of 5 cm. per minute.

When the asphalt cement as used has a penetration greater than 50 at 77°F., an increased ductility of 2 cm. shall be required for every 5 points in penetration above 50 penetration.

Binder and Laying

The binder mixture shall be heated to a temperature of between 200 and 325° and shall be mixed with from 5 to 8% bitumen. On reaching the street it shall immediately be dumped on the concrete and at once spread with hot shovels and rakes to the required thickness, after which it shall be thoroughly rolled. No more binder shall be laid at any one time than can be covered by two days' run of the paving plant on surface mixture.

Wearing Surface

The sand and the asphalt cement shall be heated separately to such a temperature as will give, after mixing, a surface mixture of the proper temperature for the materials employed. The sand when used must be at a temperature of between 250 and 375°F. The asphalt cement when used must be at a temperature between 250 and 350°F. The filler shall be added to the hot sand in the required proportions, and the two thoroughly mixed. The A. C. in the proper proportion shall then be added and the mixing continued for at least one minute.

Laying

The surface mixture shall be brought to the street in wagons at a temperature between 230 and 350°F., and shall be covered with canvas covers while in transit. It shall then be dumped on a spot outside of the space on which it is to be spread. It shall then be deposited roughly in place by means of hot shovels, after which it shall be uniformly spread by means of hot iron rakes in such a manner that after having

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received its final compression by rolling, the finished pavement shall conform to the established grade and have thickness of not less than —— inches (generally 2 inches).

Such are the specifications of the modern sheet asphalt pavement, and, in closing, there is one particular thought that should be considered. The modern sheet asphalt specifications generally require a binder course from 1 to 1½ in. thick, and a surface course from 1½ to 2 in. thick. I have never been able to discover to my satisfaction why it has been found necessary to have such a thick wearing course as of two inches. It is a well known fact that generally, after a surface course has worn much over ½ to ¾ in., the remainder of the course disintegrates very rapidly. Would it therefore not be better to reduce the thickness of the surface course to 1 in. and increase the quality and thickness of the binder course by having a very dense mixture of sand and stone mixed with the proper percentage of asphalt cement, and of a thickness approximately two inches? A pavement of this type laid under my direction more than three years ago, has given very good results, and especially in view of the fact that it was laid on a macadam foundation.

Oakland, Antioch & Eastern Railway*

By C. E. HEISE and G. B. KIRKER

STARTING from the 'Key Route' pier, the electric trains of the Oakland, Antioch & Eastern railway run over the 600-volt system of the 'Key Route,' a distance of approximately five miles to the western terminus and depot of the Oakland, Antioch & Eastern railway, where a stop is made to pick up passengers. Leaving the Oakland terminal, the track extends out Shafter avenue, in a northerly direction for about 1¼ miles through a good residential district and continues for some additional distance through one of the best new suburban residential districts of the East Bay section.

Very shortly the climb commences up the grade to the tunnel which pierces the Contra Costa hills. Leaving Oakland, the grade is 1.5% for some distance, increasing to 4.1% for about 4000 ft., then there is a level tangent about 300 ft. long and the up grade for the balance of the distance to the western portal of Shepard Canyon tunnel is 2.4%. This tunnel is the only one on the system and has a length of approximately 3700 ft., and slopes to the east on a uniform grade of 1.9%. The driving of this tunnel presented some very interesting engineering problems because of the character of the ground encountered. The eastern half of the tunnel is driven through rock, which presented no particular difficulties, a heavy timbering of standard construction being sufficient to properly hold the ground. However, in the western end of the tunnel and the approach, considerable difficulty was encountered due to swelling of the ground after the approach had been opened and a considerable portion of the tunnel driven. It finally became necessary to place a concrete lining in the western end of the tunnel and heavy reinforced concrete retaining walls were constructed at the western portal, together with reinforced concrete floorings in the shape of an inverted arch. This construction has proved singularly effective and absolutely no trouble has been experienced since the completion of the tunnel.

Leaving the tunnel, the road extends through Redwood canyon, one of the most picturesque spots in the state, the grade continuing to descend in a generally eastern direction and varying from 1.9% to practically level track, until the village of Lafayette is reached, 16 miles from the Oakland terminus. From this point, the road traverses a rolling country through the towns of Walnut Creek and Concord. This section, while really not far distant from San Francisco in an air line, has had its development held back because of lack of transportation facilities. From Concord, the road extends to Bay Point, a rapidly growing manufacturing centre, where

*Abstract from *The Electric Journal*, October 1913.

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there is a junction with the transcontinental Southern Pacific and Atchison, Topeka & Santa Fe railways.

Leaving Bay Point, the tracks parallel the transcontinental railroad systems for some distance and then cross beneath them, thus eliminating the danger of a grade crossing at this point. The construction of this underpass was no small problem, as the cut is approximately 1600 ft. in length, is built on a 6° compensated curve, the amount of material excavated was approximately 100,000 cu. yd., and the entire bottom and side walls of the cut are of reinforced concrete. The tracks of the two steam railroads are carried on steel deck trestles supported by concrete columns. From this under-pass, the tracks extend to the South Ferry slip, where the electric trains are run onto the car ferry boat and transferred across an arm of San Francisco bay to the North Ferry slip on Chipp's island.

The United States government has given the company permission to erect a bridge across this channel, but several years will be required to construct it, and the car ferry boat will serve until the bridge has been completed.

From the North Ferry slip, across Chipp's island and Van Sickle island, the road extends over marsh lands and sloughs. A fill has been made across the greater distance through these marsh lands, although some trestles have been constructed, and Montezuma slough is crossed by a centre pier revolving draw-bridge about 250 ft. in length. The line then reaches the main land, passing through the Montezuma hills and continuing through practically level country, where there is a stretch of 23 miles of tangent track, until the Yolo basin is reached, from which point a trestle, approximately 14,000 ft. long, carries the track up to a point near Glide Landing on the Sacramento river, from where the road continues on the levee for about one mile and then continues along a tangent fill for about 6 miles, entering the city of Sacramento over a steel bridge crossing the Sacramento river at M street.

After leaving Oakland the road is built on the company's private right of way the entire distance through to Sacramento, and in Sacramento the company has its own franchises and terminal sites, which are most favorably situated.

The line throughout is standard gauge, single track, with a total of about 30 sidings, each of ample length. Standard 70-lb. rails with electrically welded bonds are used. The entire length of line is efficiently protected with electric block signals.

Overhead Construction

Flexible single catenary overhead construction has been adopted as standard. The trolley is 4/0 grooved, hard drawn copper. Mounted on the poles above the bracket arms, are cross-arms, carrying the 1200-volt direct-current aluminum feeders, the telephone wires, and the block signal wires. Submarine cables cross Suisun bay and Montezuma slough, carrying the feeders, the telephone, and the block signal circuits.

Sub-Stations

Upon leaving the Oakland depot and continuing over the entire length of road up to the M street draw-bridge, at Sacramento, the trolley voltage is 1200 volts direct current.

Five sub-stations have been constructed. The one at Concord is of reinforced concrete, but the standard type of construction adopted for the remaining sub-stations, consists of a structural steel framework covered with galvanized corrugated iron.

The five sub-stations are situated approximately as follows:

Substation No. 1 is at the eastern portal of Shepard Canyon tunnel, approximately 6.4 miles from Oakland and is to contain three 750-kw. motor-generator sets with switchboard equipment.

Substation No. 2, at Concord 25.7 miles from Oakland, is to contain two 750-kw. motor-generator sets, with switchboard equipment.

Substation No. 3, at Montezuma drawbridge, 44 miles from Oakland is similar to No. 2.

Substation No. 4, at Maine Prairie, 57 miles from Oakland, is similar to No. 2.

Substation No. 5, near Glide's Landing, 78 miles from Oakland, is similar to No. 2.

The standard unit adopted for these substations is covered by the following description:

A 750-kw. two-bearing, synchronous motor-generator set consisting of one 750-kw. compound-wound, 1300-volt direct-current commutating pole generator, speed 514 r.p.m., is mounted on common shaft and bedplate with one 1080-hp. self-starting synchronous motor, wound for 11,000 volts, 3-phase, 60 cycles; and one 19-kw., direct-current, 125-volt, direct-connected exciter, complete with neces-

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sary field rheostats and apparatus for starting set from the alternating current side.

The switchboard equipment for each motor-generator consists of 1 synchronous motor panel, 1 direct-current generator panel, and 1 negative circuit breaker panel. Also in each sub-station there are three direct-current feeder panels.

Rolling Stock

The standard passenger car was adopted after careful consideration, and consists of a combination car containing passenger, smoking, and baggage compartments. It has an over-all length of approximately 56 ft. and seats 50 passengers. Each of the 14 interurban passenger cars of this type is equipped with four 600-1200-volt commutating-pole railway motors and hand operated multiple-unit control. The control is designed for full-speed operation on either 600 or 1200 volts, a change-over switch making the necessary change in motor and grid resistance connections.

Table of Distances

	Miles.
San Francisco to 40th street and Shafter avenue, Oakland	7.9
Oakland to east portal of tunnel	6.4
Oakland to Lafayette	16.0
Oakland to Walnut Creek	19.4
Oakland to Concord	25.7
Oakland to Bay Point	31.4
Oakland to West Pittsburg	37.0
Oakland to Montezuma	44.4
Oakland to Maine Prairie	56.6
Oakland to Glide Landing	78.2
Oakland to Sacramento depot	85.1
San Francisco Ferry depot to Sacramento depot	93.0

The total weight of the car, including air-brake equipment, but without live load, is 87,300 lb. The balancing speed of this equipment on level tangent track, with an average voltage of 1200 volts, is about 50 miles per hour. With an average voltage of 1100 volts, the balancing speed on level tangent track is approximately 48 miles per hour. The gear ratio is 22:55. Each of the motor cars is intended to be capable of hauling a 25-ton trailer car. There are 14 trailer cars at present and each is equipped with master controllers so that a combination train may be operated from any car.

There are also two combination passenger and express cars of similar description. One car has a gear ratio of 18:59 and the other 16:61, so that these cars can be used for hauling a number of trailers or a freight car where necessary.

On account of the long and heavy grades, it was deemed necessary to insure a suitable supply of air available in any emergency, and for this reason two dynamotor-compressors were installed on each motor car, each compressor having a capacity of 25 cu. ft. of free air per minute.

To take care of the heavy through passenger business between San Francisco and Sacramento, two type 2-4-0, articulated truck, high speed electric locomotives are used, with four commutating pole, field control, 600-1 200-volt motors and unit switch control. Each locomotive is capable of hauling five steel passenger trailer cars, weighing 37.5 tons each, on level tangent track with 1100 volts on the trolley, at a balancing speed of about 56 miles per hour. When hauling only three of these passenger cars, the balancing speed, under the same conditions, will be approximately 60 miles per hour. Each locomotive has a total weight of 62 tons, of which 43 tons is carried on the drivers and 19 tons carried on two radial pony trucks. The draw-bar pull is transmitted through the main truck side frames and each driving axle is equipped with an independent geared motor. The driving wheels are 42 in. diameter and the gear ratio 26:47.

With forced ventilation the locomotive is capable of exerting continuously a tractive effort of 4400 lb. on normal field with an average of 500 volts, and 8500 lb. for one hour on normal field at approximately 45 miles per hour with 1200 volts, while with clean dry rails, the locomotive is capable of exerting momentarily a maximum tractive effort of 21,500 lb. The motors have a nominal rating of 250 hp. with forced ventilation.

The motors and control equipment are designed for 'field control,' enabling the locomotives to exert relatively high tractive effort when the motors are operated on full field and securing maximum speed when the motors are operated on normal field. Each locomotive is equipped with two dynamotor-compressors, each compressor having a capacity of 35 cu. ft. of free air per minute and sufficient capacity to supply the required amount of 600-volt direct current for lighting the trailer cars, the locomotive head-

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light and for operating the control. Mounted on the extended shaft of each dynamotor-compressor, is a blower which supplies the forced ventilation to the main locomotive motors.

For handling the freight business, there are two 47-ton freight locomotives, each equipped with four motors and hand operated unit-switch control, and using a gear ratio of 17:56 with 42-in. wheels. Each locomotive is capable of developing a full-load tractive effort of 16,600 lb. at a speed of 10.6 miles per hour with 600 volts, or a continuous tractive effort of 5200 lb. with 600 volts, or a maximum tractive effort of 24,500 lb.

Each freight locomotive is provided with two independent dynamotor-compressors, each having a capacity of 25 cu. ft. of free air per minute.

The passenger cars are equipped with roller pantograph trolleys and the passenger locomotives with double shoe, sliding pantograph trolleys.

The road was opened for service between Oakland and Bay Point in April 1913, and through service between Oakland and Sacramento was inaugurated on September 3, 1913. Power is purchased from a long distance hydro-electric power transmission system at 11,000 volts, 3-phase, 60 cycles, delivered to the various sub-stations, where it is stepped down to the operating pressure.

A Method of Preventing Corrosion of Iron and Steel

As a part of its investigations relating to efficiency in mining, the Bureau of Mines has undertaken to develop a method of preventing the corrosion, by acid water from mines, of iron and steel used in mine equipment. Technical Paper 15, 'An Electrolytic Method of Preventing Corrosion of Iron and Steel,' describes experiments in connection with an electrolytic method of preventing corrosion. The results appear to justify the hope that the method may be applied successfully for the protection of iron and steel in the construction of mining equipment, as well as for the protection of structures exposed to the acid waters of streams.

According to the electrolytic theory of corrosion, the corrosion of iron is an electrolytic process. The iron goes into solution as ferrous ions, and these ferrous ions are oxidized by the oxygen present in the water to ferric ions and precipitated as ferric hydroxide or iron rust. Simultaneously with the formation of the ferrous ions, hydrogen is liberated on the surface of the iron. The formation of ferrous ions and the liberation of hydrogen are accompanied by a transfer of electricity. The electric current flows through the metal from the point where hydrogen is liberated to the point where iron is dissolved; and through the electrolyte from the point where iron is dissolved to the point where hydrogen is liberated.

If, now, a counter electromotive force be imposed, the current may be made to flow in the opposite direction, and the solution of the iron may be prevented. This fact has been made use of previously in an electrolytic method for the protection of boilers against corrosion. The method consists in submerging a bar of zinc in the boiler water and connecting the zinc electrically with the boiler plates.

In the experiments of the Bureau of Mines, carbon was used as the anode in place of zinc, and the electromotive force required was furnished by a storage battery. Experiments were made on steel plates 1 by 2½ in. immersed in sulphuric-acid solutions. Suitable arrangements were provided for renewing the acid and for stirring the electrolyte. It was found that the current density required to protect the plates depends on the strength of the acid solution, the amount of oxygen gas present in the electrolyte, and the acid construction. The first-named factor is probably of least importance, especially in dilute solutions. The rate of flow of electrolyte over the surface of the metal is by far the most important factor.

With the lowest rate of stirring used in the experiments, 35 r.p.m., and in acid concentrations not greater than 0.01 normal (500 parts per million), a current density of from 0.5 to 0.8 milliamperes per square inch reduced the corrosion loss to a negligible quantity, whereas with the stirrer rotating at a speed of 450 r.p.m. and a current density of 2 milliamperes per square

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inch the corrosion loss amounted to 25% of the loss on the unprotected plate.

It was found that the current density required could be calculated from the loss in weight of the metal under the given conditions when not protected and the electrochemical equivalent. Taking 1 milliampere per square inch and 5 volts as current density and electromotive force required to prevent corrosion under given conditions, then the power consumption per square foot protected surface would be approximately 0.75 watts, and the electric energy $\frac{0.75 \times 24 \times 365}{1000}$ = 6.6 kw-hr. per square foot of surface per year (or 0.61 kw-hr. per square metre of surface per year).

The laboratory tests were supplemented by tests on a large scale with steel plates immersed in the Monongahela river at Braddock, Pennsylvania, the waters of which contain acid from the bordering steel mills and other industrial plants.

Maximum Loads of Transmission Lines*

By H. B. DWIGHT

THE recent increases in the lengths of transmission lines and high-tension networks have made the cost of the line itself the item of most importance in planning a large transmission system. The question, therefore, arises: With how cheap a line or with how few lines can a given block of power be transmitted? Or, in other words: What are the limits to the loading of a transmission line? In the present article, the various factors limiting the loading of a transmission line are outlined and their relative commercial importance is indicated, so as to show what calculations of electrical characteristics and costs should be made in determining the proper line for a given case. A distinction is made between items which are a serious economic disadvantage, and others which, while presenting engineering difficulties, do not greatly affect the costs if the difficulties are properly taken care of.

The amount of power which any transmission line can carry is always increased if the operating voltage is raised. The theoretical limitation to the voltage is imposed by the formation of corona on the conductors, since if the voltage is raised beyond the point at which corona appear, the energy loss due to the corona quickly reaches a prohibitive amount. The limiting operating voltage depends on a great many factors, among which are the size and spacing of conductors and the altitude above sea-level.

Varying-Voltage Lines

The usual method of controlling a transmission line is by adjusting the generator voltage so as to give uniform voltage at all times at the receiving end of the line. This may be called the varying-voltage method of control, since at all points on the line, except one, the voltage varies as the load changes. The limit of the load which the line may carry under those conditions is set by the maximum allowable variation in voltage. The maximum variation may be taken as 20% since power cannot very well be sold to a customer, or the station apparatus satisfactorily operated, where the variation in voltage is greater than this amount.

In most transmission lines the reactance is greater than the resistance, and is the chief cause of voltage variation. Any addition to the reactance reduces the amount of power which can be delivered. It has been found advisable in large systems to install high-reactance coils to protect the station apparatus from the effects of short-circuits and surges in the line. The use of such reactance coils with a varying-voltage line directly reduces the maximum load of the line. Since in ordinary cases the voltage variation due to reactance and resistance becomes excessive before the energy loss reaches a serious amount, the cost of energy for line losses does not set a limit to the amount of power transmitted by a varying-voltage line. In other words, the full-load

*Abstract from *The Electric Journal*, September 1913.

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efficiency of such lines is generally high.

The characteristics of a typical line are shown in Table I. Usual amounts of reactance are assumed for transformers and protective coils at the ends of the line. The load to which power is delivered is assumed to be an ordinary city load with a power factor of 85%. In a line 200 miles long the charging current, due to the condenser effect of the conductors, assumes a large value, and it is useful to determine whether this current is a help or a hindrance. For this purpose, Table I shows also the results of the calculations when the line is assumed to have no charging current. This is equivalent to considering a line of, say, 30 miles in length, which has, due to a different size of copper and different protective coils, exactly the same number of ohms of resistance and reactance as the 200-mile line. From Table I it is seen that with the charging current more power can be transmitted and the generator power factor and the transmission line efficiency are higher. As far as the above points are concerned, the charging current is evidently advantageous.

It is often complained that, owing to the charging current, full kilovolt-amperage must be carried by one or more generators when no power is being delivered at the receiver. This does not seem a very reasonable complaint, for no great expense is involved, and, as shown by Table I, the gains due to the charging current at full load more than compensate for the losses at no load. The charging current really improves the load factor, making it easier for the generators at times of heavy load, and adding to their load at other times.

A phenomenon to be noted in transmission-line operation is the rise in voltage when the load is suddenly disconnected, the excitation of the generators being for the time unaltered. This occurs when the circuit-breakers at the receiver end open. The example in Table I shows that at such a time the voltage on the line may rise to a steady value of approximately twice normal voltage. While this is a considerable strain on the insulation of the line and the

	Line 200 miles in length, with transformers and protective coils at each end	Short line of same electrical characteristics, but without capacity
Frequency, cycles	60	60
Maximum voltage at generator end	115 000	115 000
Minimum voltage at generator end	92 000	92 000
Steady voltage at receiver end	108 000	92 000
Kilowatts delivered	10 100	8 200
Power-factor of load, lagging, percent	85	85
Efficiency of transmission at full load, percent	95	93
Generator k.v.a. at full load	11 900	12 100
Power-factor at generators, lagging, percent	89	73
Generator k.v.a. at no load with normal voltage at receiver	10 400	0
Approximate voltage at receiver end when the receiver circuit breakers open, enough generators being connected to carry the charging current	200 000	155 000

Conductors—250 000 circ. mils. copper cable.
Spacing of conductors—10 feet, flat spacing.
Mean spacing of conductors—$\sqrt[3]{10 \times 10 \times 20} = 12.6$ feet.
Resistance of line per conductor—45.7 ohms.
Reactance of line per conductor—160 ohms.
Capacity susceptance of line per conductor—0.00107 ohms.
Resistance of transformers and protective coils at each end, referred to high tension—4.1 ohms.
Reactance of transformers and protective coils at each end, referred to high tension—64.5 ohms.

TABLE I. VARYING VOLTAGE LINES. NO SYNCHRONOUS CONDENSERS USED.

A phenomenon to be noted in transmission-line operation is the rise in voltage when the load is suddenly disconnected, the excitation of the generators being for the time unaltered. This occurs when the circuit-breakers at the receiver end open. The example in Table I shows that at such a time the voltage on the line may rise to a steady value of approximately twice normal voltage. While this is a considerable strain on the insulation of the line and the

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station apparatus, it is to be remembered that even greater strains are often imposed by the high transient voltage caused by lightning or the opening and closing of circuit-breakers. It is also shown by the example in Table I that the increase of line voltage on the opening of the circuit-breakers at the receiver end is greater when there is charging current than when there is none, as in a short line. The percentage regulation of a generator between a lagging load of low-power factor and no load is not nearly as large as the regulation between a lagging load and full load with leading current. In the latter case the leading current magnetizes the generator to a rather high voltage.

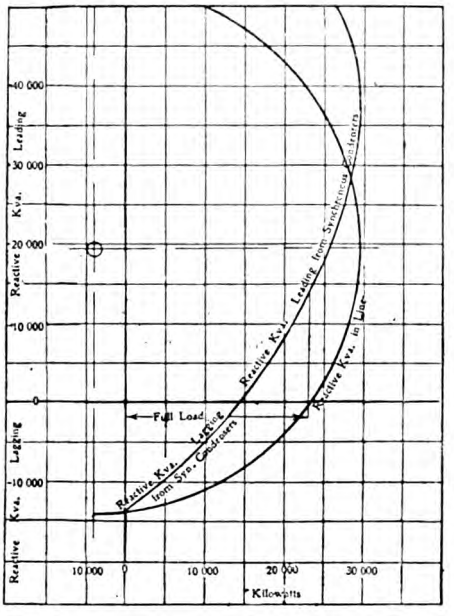

FIG. 1. DIAGRAM FOR CONSTANT VOLTAGE TRANSMISSION LINES.

In addition to the generator regulation, there is a rise in voltage along the line when there is charging current, due to the Ferranti effect. By this effect, when the receiver end of a line is not connected to any load, the voltage at that end is a certain percentage higher than the voltage at the geneartor end. Since the receiver end is disconnected, the only current which is possible must flow into the transmission line as into a condenser, and it therefore leads the voltage in phase. The transmission line along which this leading current is flowing contains reactance, and there will accordingly be a rise in voltage due to the current.

The phenomenon of the increase of voltage when load is thrown off is not to be considered a limitation to the loading of transmission lines. The increase may be very great on a line carrying only a small load supplied by a single generator. The same line may have a smaller increase in voltage, when its load is several times as great as before, if enough generators are used. If the increase is very marked, it can be minimized by keeping enough generators on the line to carry the charging current easily, even at high voltage, in case the receiver circuit-breakers open, and by arranging for close regulation of the generator voltage. If the above precautions are not taken, this phenomenon may in some cases prove to be as dangerous as the transient voltages which are such a well known cause of troubles in transmission systems.

Although the voltage rise may be almost as great on a 60-mile line as on a 200-mile line, it has not as yet proved to be a very serious difficulty in line operation. Since it is exaggerated by the charging current, the latter must be considered to be a disadvantage in so far as the phenomenon of voltage rise is troublesome.

CONSTANT-VOLTAGE LINES

The use of synchronous condensers, by means of which transmission lines can be operated at constant voltage and with largely increased loads, is coming into prominence, as it effects distinct improvements in service and large savings in transmission-line costs. The study of such lines is comparatively new, and the limitations to loading must be looked at from fresh viewpoints. Constant voltage operation involves the installation of synchronous condensers in large quantities at the receiver end of the line, under the control of the operating company. Their excitation is varied so as to furnish enough leading current to overcome the effect of the load current. It is well known that leading current, such as is furnished by synchronous condensers, tends to cause a rise of voltage in a transmission line. By this means the voltage at both the generating and receiving ends may be kept steady. The voltage at intermediate sub-stations may be kept constant in the

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same way, if synchronous condensers are installed there.

Althougn the cost of the synchronous condensers is large, the extra expense is in many cases justified, especially with long transmission lines, because it results in large savings in the cost of the line itself. For instance, the use of synchronous condensers more than doubles the capacity of a line for carrying power; in other words, for a given amount of power, a cheaper line or fewer lines will suffice. This is due to synchronous condensers required. Allowance has been made for the capacity of the line as a condenser in the calculation, and the curve is found to be part of an ellipse. Since part of the leading reactive kva. furnished by the synchronous condensers is used to correct the low power-factor of the load, the curve of reactive kva. actually in the transmission line is different from the synchronous condenser curve, as may be seen from the figure. This latter curve may be shown to be a circle, even when the

	Line 200 miles in length with transformers and protective coils at each end	Short Line of same electrical characteristics, but without capacity
Frequency, cycles	60	60
Constant voltage at generator end	115 000	115 000
Constant voltage at receiver end	81 000	81 000
Efficiency of transmission at full load, percent	85	85
Kilowatts delivered	23 100	21 100
Power-factor of load, lagging, percent	85	85
Synchronous condensers required at full load, k.v.a.	13 900	15 800
Synchronous condensers required at no load, k.v.a.	13 900	9 500
Generator k.v.a. at full load	29 600	30 300
Power-factor at generators, lagging, percent	92	82
Theoretical limit of load, kilowatt	29 600	27 600
Generator k.v.a. at no load and at normal voltage	7 100	13 500
Approximate voltage at receiver end when the receiver circuit breakers open, enough generators being connected to carry the charging current	200 000	150 000

TABLE II. CONSTANT VOLTAGE LINES. NO SYNCHRONOUS CONDENSER USED. (SAME LINE DATA AS GIVEN FOR TABLE I.)

a change in limits. The limit of voltage variation, of course, does not apply, since the voltage is kept steady, and so the amount of power can be increased until the energy loss becomes too great for good economy, or, as sometimes happens, until the cost of required number of synchronous condensers becomes excessive. In the example shown in Table II, the energy loss limit becomes operative, for 85% is a rather low efficiency for a transmission line.

In Fig. 1 a curve is shown of the kva. in synchronous condensers needed at various loads for the 200-mile line described in Table II. In plotting this curve, the abscissae are kilowatts of power delivered by the line. The ordinates are kva. of charging current is allowed for.

The curve of synchronous condenser kva. is seen to bend rapidly upward when the load is increased beyond 25,000 kw. The load approaches a limit of 29,600 kw. More power than this cannot possibly be delivered by a line of the specified impedance and supply and receives voltages, no matter what assumptions are made regarding efficiency or number of synchronous condensers. This limit may be called the theoretical limit of tne load. Before the theoretical limit is actually reached, the proportionate cost of synchronous condensers becomes excessive, and the load cannot therefore be economically increased. It is in this way that the effect of the theoretical limit is

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felt in actual practice. The number of synchronous condensers can sometimes be decreased by lowering the receiver voltage, so as to use as many condensers at no load as at full load. The example in Table I shows about as low a receiver voltage as would generally be considered desirable. If a higher receiver voltage is desired, all that is needed is to supply more synchronous condensers for use at full load.

The 200-mile line described in Table II is typical of most transmission lines in that the theoretical limit is not nearly approached, but the load transmitted by the line is limited by the cost of power for line losses. However, where the cross-section of the conductors is very large, and where large protective reactances are used, the efficiency is high for loads close to the theoretical limit. For such lines, the maximum load is settled by the theoretical limit. Lines with such a high ratio of reactance to resistance as this are rather unusual at the present time, as they would not be economical for the usual varying-voltage method of control, but would be likely to be designed only for constant-voltage transmission.

The addition of protective reactance coils directly reduces the theoretical limit of load, but it does not increase the losses to any great extent. Since most practical lines have excessive losses before the theoretical limit is approached, it is evident that high protective reactances can be used economically on constant-voltage lines. For the same reasons, the high reactances encountered with the frequency of 60 cycles are not a very great disadvantage, and the frequency of 60 cycles is, therefore, put on an equality with 25 cycles for economical transmission work, by using the constant-voltage method of control.

The excessive rise in voltage when the receiver circuit-breakers open occurs with constant-voltage lines as well as with those operated with varying voltage. The same remarks apply to this phenomenon as were made in the discussion in connection with varying voltage lines, namely, that it does not affect the maximum permissible load, and that it can be taken care of with proper precautions.

As was noted in connection with varying-voltage lines, the charging current is in some ways advantageous, and in some respects disadvantageous. It is not of very great commercial importance in planning transmission lines, although it requires considerable attention and care for its proper control. With constant-voltage lines, it increases in some measure the amount of power which can be transmitted at a given efficiency and voltage, and it also tends to raise the generator power-factor. On the other hand, it increases the rise in line voltage when the circuit-breakers at the receiver end open.

Summary

For transmission lines, the line voltage is limited by the phenomenon of corona.

The limit of the load on a line operated without synchronous condensers is variation in voltage.

The load limit for a line operated at constant voltage by means of synchronous condensers is much larger than the above limit, and the limiting condition is usually low efficiency.

For heavy lines, with large reactance, or where the cost of power for line losses is low, the theoretical limit for constant-voltage lines may be approached, which will involve increased cost of synchronous condensers.

The charging current is of small commercial importance, even though it may be large in amount, and must be carefully allowed for. In general it may help; its main disadvantage is that it increases the voltage rise when load is suddenly disconnected from systems not closely regulated.

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Practical Mathematics*

(As written for *Nature*.)

HERE in the United States of North America we also have our troubles in teaching of the mathematical sciences to engineering students, and many of us have followed with great interest the movement which has been led by Professor Perry in England. In his discussion of practical mathematics, Professor Perry certainly has our most serious troubles clearly in mind, whereas the recently appointed head of the Imperial College, who belittles the work of Professor Perry and urges that mathematics be taught by professional mathematicians, is, we are sure, profoundly ignorant of these troubles, and he seems only to see certain crudities in Professor Perry's work.

We believe that no one should venture to pass judgment in this matter of mathematics teaching who does not know something of present results as shown in the immediately subsequent study of the mathematical sciences, and we hope that the most prominent recent critic† of Professor Perry may read what we have set forth herein. We begin with a suggestion which is intended to strike horror into the breast of a practical man such as we naturally assume Professor Perry's critic to be—the kind we know here at home.

The philosophy of the seventeenth century for us of the twentieth! Indeed it would be well so, if thereby we might put to shame our ostentatious practical worship, and temper the too insistent judgment of our so-called practical men. "The real and legitimate goal of the sciences," says Bacon, "is the endowment of mankind with new inventions and riches." What practical man of the twentieth century could say more than this? And if this was good philosophy for the seventeenth century when scientific work was still extremely remote from the doings of men, what limit can be set to the same kind of philosophy now when science has come to touch every condition of life? Indeed as William James has said, this kind of philosophy is not limited, and it gives promise of a conquering destiny! Let practical men understand that some philosophers and teachers nowadays outdo them all in unostentatious acceptance of practical ideals; and the chief concern of the practical man who enters the teaching sphere should be to remain practical and not become academic.

Among the things listed by Bacon as needed in his time was 'A New Engine, or a Help to the Mind Corresponding to Tools for the Hand.' In this statement Bacon referred to the entire body of scientific method, not, as many of our engineers seem to imagine, to mathematics alone. Indeed the development of workable ideas in the mind of a young man is one of the most important objects of elementary teaching, but many mathematical teachers seem to think that ideas can be

*The John Perry movement for the reform of mathematics teaching was severely criticised at the International Mathematical Congress a year ago, and the criticism was reflected in a letter by Professor Perry in *Nature* of September 12, 1912. The personal element in Professor Perry's letter excited in us a strong feeling of sympathy for him, and aroused in us a degree of antagonism for the then recently appointed head of the Imperial College who posed as a practical man.

The above paper by W. S. Franklin and Barry MacNutt was sent to *Nature* on November 7, 1912; but a delay in transit resulted in its delivery to the editor of *Nature* on January 31, 1913, when it was thought to be out of date and therefore not available for publication.

The paper was then sent in a slightly altered form to the Editor of *Science*, who agreed to publish it; but we finally decided not to publish it at all until we could alter it so that it need not be published anonymously, or until we could send it out to a private list of correspondents.

When the paper was written we had, as yet, no thought of writing an elementary treatise on calculus, but our experience during the fall of 1912 drove us to the undertaking; and we consider that there would be some impropriety in the use of thinly veiled anonyms now that our elementary treatise on calculus has come off the press.

FRANKLIN, MACNUTT, AND CHARLES.

†Sir William White, the Director of the Imperial College of Technology, who died in February, 1913.

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built up in a young man's mind by a sort of hocus pocus out of nothing! Ideas, however, like everything else in this world, must be made out of something, and the problem of elementary science teaching is largely the problem of how by suggestion or otherwise, to drag sense material into the field of consciousness where it may be organized into a structure of ideas. In the teaching of mathematics every effort should be made to appeal to sense material and to the quantitative notions which permeate everyday life; and mathematical principles and relations should be visualized wherever it is possible.

Many teachers of calculus, do, no doubt, appeal to sense material, and what we say as to the urgent importance of such appeal is likely to be lost on them; for we have in mind a degree of appeal which is greater, perhaps, than has ever been attempted, and especially we urge the importance of incorporating this appeal in the printed text. Men have but little native ability to understand impersonal and non-anthropomorphic writing, and nothing in elementary science training is more important than to develop this kind of ability. It depends not only upon the possession of ideas but it demands the acquirement of some of these ideas by reading.

According to our experience, engineering students willingly spend almost any amount of time and effort in algebraic transformations, in memorizing formulae, and in solving numerical problems, but they cannot be made to read with care the briefest written statement or argument however simple it may be be and however clearly written, and when they do read they cannot understand. This obstinate unwillingness to read and this fixed inability to understand are due very largely, we believe, to the influence of our mathematics teaching. What else could be expected when the great majority of engineering students never get a single idea from the book they study hardest—and hate the worst—their text book on calculus?

Professor Sylvester once said that during his undergraduate days his liking for calculus led his mates to look upon him with a kind of awe as a man who like Dante had seen Hell. But to study calculus without understanding is Hell; and the man to be likened to Dante is he who sees young men study, knowing that they do not understand! But let us turn from generalities to particulars.

Several years ago we gave the following original problem to a group of freshmen engineering students as part of a final examination in elementary mechanics.

"A cart moves due northward at a velocity of 11 ft. per second. A man pushes downward on the cart with a force of 200 lb. and a mule pulls northward on the cart with a force of 50 pounds. At what rate does the man do work and at what rate does the mule do work?"

Forty-four per cent of the class found that the man was developing 4 hp. and mule 1 hp. These students were not exactly stupid, either; they were merely wild Indians of a very familiar and ubiquitous kind; their physical imagination had never been stretched beyond games and guns, or, maybe, never beyond articles of food and the members of their bodies! It is certain, at any rate, that to have specified the part of his body used by the man in the problem in pushing against the cart would have brought the problem before every member of the class in its real aspects! Or, perhaps, many of the class were obsessed with the idea that any study in college must necessarily refer to elegant and unfamiliar things, like the boy who was asked to explain what is meant by the heat of combustion of coal. This boy answered at once, "It is the amount of heat obtained from a pound of coal," but he could not be led to say "when the coal is burned." And when the instructor finally put the direct question, "How do you get heat out of coal?" the boy answered, stammering, "Why, professor, I—I don't know."

This identical boy, who seemed not to know that coal must be burned to get heat out of it, came upon the following statement on the 23rd page of his calculus in a two-page discussion of discontinuous functions, and he came upon it several months before the question as to the heat of combustion was put to him:

"Another discontinuity is seen in the function $y=\frac{2^{\frac{1}{x}}+2}{2^{\frac{1}{x}}+1}$ when $x=0$. Here y approaches two limits, according as x approaches zero through positive or negative values.

$$\lim_{x=+0}\frac{2^{\frac{1}{x}}+2}{2^{\frac{1}{x}}+1}=1 \qquad \lim_{x=-0}\frac{2^{\frac{1}{x}}+2}{2^{\frac{1}{x}}+1}=2$$

We see that when $x=0$ the curve jumps from $y=2$ to $y=1$, that is from B to A (referring to a figure)."

In all probability, after 'seeing' y jump in this elegant and unfamiliar way, the boy

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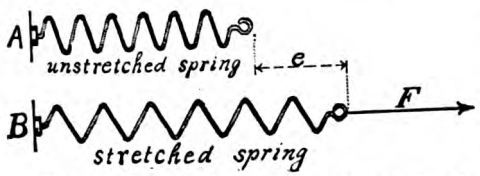
really did not remember that coal must be burned up to get heat out of it! Please recall Sylvester's allusion to Dante and consider what Dante saw (and understood, be it said to his everlasting fame), souls who had abandoned hope—and their tormentors!

Let us take another example. We recently gave to a group of junior engineering students two problems involving the use of calculus and there exists no problem involving the use of calculus which is simpler than either of the two we gave. The simpler of the two problems was as follows (the sketch here shown was given to make the problem perfectly clear):



"The stretching force F, as shown in the sketch, is equal to ke where k is a constant. Find the expression for the amount of work done in stretching the spring from condition A to condition B."

There were 33 students in the class who had passed all of their freshman and sophomore mathematics, including analytical geometry, differential calculus, integral calculus, differential equations, and analytical mechanics. Only 4 men formulated the problem correctly and derived the correct result; and of the 29 who failed utterly with a grade of zero 13 tried to argue the problem without using calculus! And yet, in the institution where this degree of mathematical power is realized, from 40 to 60% of the men fail to pass in each of the four successive terms of mathematics!

Teachers of calculus seem to place an excess of emphasis upon the more elaborate and formal aspects of the subjects, and our students are left almost totally incapable of setting up mathematical formulations on the basis of physical specifications. Every discussion in calculus for the beginner should start with simple physical considerations, and after the quantitative aspects of the case have emerged the more elaborate mathematical formalities may be attended to. If any one objects to this procedure as unimaginative let him understand that the most remarkable thing in the whole range of the mathematical sciences is the wonderful significance and scope of quantitative relations as exemplified in modern rational physics, which is as purely a branch of mathematics as geometry; indeed, rational physics now completely overshadows geometry as by far the most imaginative branch of mathematics. The widespread tendency toward the premature introduction of mathematical refinements and elaborations is perhaps one of the most serious faults in teaching. "Natural philosophy," says Bacon, "is not yet to be found unadulterated, but is impure and corrupted by mathematics, which ought rather to terminate natural philosophy than to generate or create it."

We have tried to keep away from vague generalities in the preparation of this brief, and yet in looking it over we realize that many of our statements grow out of very general considerations indeed. It could not, perhaps, be otherwise, but our point of view seems to be different from that of most of our fellow-teachers, and therefore not to be easily understood by them. We assume, however, that most teachers recognize sorely the need of what Bacon listed as a deficiency in his day, namely, 'The Traditive Lamp or the Proper Method of Delivering Down the Sciences to Posterity.' We also assume that some teachers of elementary mathematical science are not wholly pleased with what they do. But especially, recognizing the very great preponderance of what may be variously called ideas, or method, or theory, in what is teachable in science, we recall this humiliating passage from Goethe:

"Grau theurer Freund ist alle Theorie
Und grün der Lebens goldener Baum."

A pair of complementary imaginary anonyms:

$$a + b\sqrt{-1} \text{ and } a - b\sqrt{-1}.$$

Discussion

Apparatus to Fight Liquid Fuel Fires

The Editor:

Sir—The fire at the Standard Oil Company's storage plant, at San Diego, on Oct. 5, 6, and 7, when some 1,000,000 gallons of crude oil and lesser quantities of other oils were consumed, brings us face to face with the inefficiency of ordinary fire-fighting apparatus when opposed to a conflagration of liquid fuel.

The fire started in the distillate tank,

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which, at the time, was being replenished from an oil tank steamer. The cause of the fire will probably never be known. The only known facts are that there was an explosion that blew off the top of the tank, and the content immediately burst into flame. It would seem probable that the vent that allows for the escape of air, as the liquid rises in the tank, became stopped, in which case either of two things might happen. The internal pressure might have been more than the tank was able to bear, so the top blew off, and the escaping gases, which would be an explosive mixture, came in contact with some flame and flashed it back to the tank; or it is possible that the compression of the gases caused sufficient heat to bring about their ignition, and an explosion resulted.

The distillate within the tank burned quietly for a time, and poured forth an enormous volume of black smoke, which was proof that the combustion of the fuel was far from complete. As the oil was heated by the fire, much of it was converted into a gaseous form, and the gases rising to the top of the tank met with more oxygen, and the fire became hotter.

The fire department, knowing that with the apparatus at hand they were powerless to extinguish the burning oil, directed their efforts toward the other tanks, and kept a stream of water playing on them, in the hope that they might be kept below the ignition temperatures of the oils they contained. Efforts in the main were futile, as several of the other tanks were fired. It is estimated that, altogether $200,000 worth of liquid fuel was destroyed and some $50,000 damage done to the plant.

The only hope of successfully fighting a fire of liquid fuel, such as oil, which is not miscible with water, is to cut off the supply of oxygen. When the fire is confined, as in an oil tank, it would appear that the simplest way to cut off the oxygen would be to superimpose a layer of carbonic acid gas on the oil. In the early stages of the fire at San Diego, if a 2-in. pipe shaped at the end like a 'U' had been placed over the top of the tank in such a way that the end was reasonably near to the oil, and a rapid stream of carbonic acid gas run in, there is little doubt, in my opinion, that the fire would have been extinguished in a few minutes, and much valuable property saved. It would almost seem that the gear by which to have done this might have been made out of an empty oil tank and piping, and surely baking soda and sulphuric acid could have been obtained.

Fortunately there was little wind during the fire at San Diego, so, with the exception of some 50,000 ft. of lumber that was destroyed in a near-by yard, the damage was confined to the property of the Standard Oil Co. Had there been a high wind during any part of the two days that the fire lasted, there might have been a different tale to tell. With the ever-increasing use of gasoline and liquid fuel it would seem that for the safety of property owners in the vicinity where liquid fuel is stored in quantity some better form of fire-fighting apparatus should be kept on hand.

F. H. Mason.

San Diego, October 17.

Hints on Practice

Instructions for Laying Machine Banded Wood Stave Pipe*

Handling

Care should be taken when unloading wood pipe from the cars or boat, and also in hauling the pipe from shipping point to point of installation. Workmen should be instructed not to drop the pipe on end, but to carefully lay it upon its side when handling same. Be particular and see that the tenon ends are protected.

Tools Required

For each gang of pipe layers when handling pipe in sizes from 2 to 8 in. inclusive the following tools are recommended:

1 tompion,
1 maul,
1 pair light pipe tongs,
For pipe 8 in. diameter and over,
1 tompion,
1 tripod or wheel ram.

Tompions are made of wood with the end banded with iron to prevent splitting, and fit the end of the pipe to afford a driving surface. The balance of the tools are so well known that they call for no further description.

Labor Required

In laying the smaller sizes of pipe three

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men are required, two to stay in the trench and take the pipe from the bank above, one workman entering the tenon end of the pipe into the coupling of the joint of pipe previously laid, the other workman at the forward end assisting him in doing so, and at the same time seeing that the pipe is in line with the last joint laid. This forward workman inserts the tompion into the end of the pipe so that the third workman who handles the maul can drive it into place. In case the tompion rebounds when struck, a rope may be attached to each side and the man whose duty it is to insert the tompion can hold it in place. As soon as the pipe is driven together the forward workman draws the tompion out of the pipe, carries it to the front at least a joint's length, and then assists in lowering another joint of pipe. The work is continued as above.

In handling large sizes of pipe more men will be required.

Laying Pipe

Place the pipe with the coupling or mortise end forward. The workman who inserts the tenon end must watch closely and see that it is started around the entire circumference of the tenon. The workman using the maul or ram should at first tap the pipe lightly so that the workman stationed at the joint being driven will have time to see that a proper connection is being made. Drive each joint to the shoulder of the tenon, and see that the last joint laid is in line with the joint previously laid. When laying the pipe around a slight curve lay the joints as nearly straight as possible, and spring the pipe to conform to the curve after it is driven up and connection made. Use short lengths of pipe in making curves and brace each joint by staking the outside in the middle of the joint. It is necessary to drive stakes firmly into the ground, and not depend on blocking between the pipe and the bank of the trench. When rock is available it can be used to good advantage.

Cutting and Fitting Pipe

If it is necessary to cut a joint of pipe to make a short length or to fit some connection; first mark the place the pipe is to be cut; second, measure back on the joint of pipe a distance sufficient to allow for the tenon end; third, staple the banding at the second joint and work back against it with chisel and hammer two turns of the banding. These two turns of the banding to be worked back from the part of the pipe to be used for the tenon end, and with the one already stapled gives the three turns desired. A clip should then be inserted under the three wraps of wire and the prongs of the clip driven down on same. The banding then should be cut, leaving about 6 in. free to be bent back and stapled. When the banding is fastened in this manner it will appear similar to the fastening as made at the factory. If desired in fastening the banding staples may be used in place of a clip, but never cut tne banding before it is securely fastened. After cutting the pipe the tenon end is worked down by using a draw knife and coarse wood rasp. Care should be taken not to cut too deep and the wood rasp should be used in finishing the tenon.

Placing Fittings

In placing fittings and gate valves great care should be taken so that the tenon end of the pipe is sufficiently large to fill the opening in the fittings. In the event it is not, a new tenon should be made sufficiently large to make a tight fit. When necessary to insert a fitting or to lay the pipe from each end and connect where the two lines meet, it is necessary to buckle the last two joints of pipe as follows: Carefully raise both ends of the pipe to be connected until the tenons can be inserted into the fitting. It is advisable to raise more than one joint on each side of the fitting so as to prevent straining the pipe at the connections. After the tenons are inserted in the fitting press the pipe into place. It will be necessary to tap the coupling lightly with a maul, this together with the weight of two or three men will lower the pipe into its proper position in the trench. All tees, ells, and plugs or dead ends must be securely blocked. Where practicable, concrete should be used. In other cases, rock may be broken and used to good advantage by being tamped between the fitting and the side of the trench. Never use wood blocking for pumping lines or high pressure pipe.

Individual Banded Collars

In laying pipe with individual banded wood collars it is advisable where practical to drive joints together the same as machine banded collars. Be sure, however, to have the nuts on the bands at the top of the pipe so that they are readily accessible when necessary to tighten the bands. Where it is not practical to drive the joints together it

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will then be necessary to slack the bands on the collars, insert the pipe into the collars, and when properly placed tighten up the bands. Care should be taken not to tighten each band separately, but to equally distribute the tension over the entire number of bands, used on the collars. This is important to avoid stripping the threads. While the bands are being tightened up it is advisable to tap them with a hammer, thus adjusting the collar to the tenon and making a close wood to wood connection.

Cast Iron Collars

Cast iron collars are shipped loose ready to put on the pipe when laid in trench. When laying wood pipe with cast iron collar connections, begin by driving a collar on the first joint laid, using a heavy wood maul, or an iron sledge and a hard wood block to strike on. Care should be taken not to crack or chip the collar. After the first collar is in place, insert the next joint of pipe and place the second collar in position, then drive it on to the joint. After the second collar is driven up to the shoulder insert the tompion and drive tenon at the first joint full into the collar. If a collar leak should develop, do not drive a wedge between the collar and the tenon, but cut into the stave about ½ in. from the end of the collar, using a sharp thin chisel, slanting same enough so that when the wedge is inserted in the incision it will follow parallel with the grain of the wood and force the stave up against the collar.

Steel Collars

In laying pipe fitted with steel collars be sure and lay the seam or riveted side of the collar up. Small leakage can usually be stopped by striking the collar a sharp blow with a light hammer.

Wood Collars

Leaks may be stopped by driving wedges into the end of the collar about ½ in. from the connection between the tenon and the collar, thus forcing the wood in the collar down on to the tenon.

Mortise and Tenon Connections

Leakage can usually be stopped by driving thin wedges under the banding on the mortise end, thus forcing the mortise down on the tenon. Do not drive wedges between the mortise and tenon connection. (See special instructions relative to reinforced inserted joints.)

Calking Wood Pipe

It is advisable to install wood pipe as soon as possible after it is received, and if the above instructions have been carefully followed there should be but slight leakage which will take up in a short time.

Seam Leaks

In case a seam leak should develop drive a thin sharp wedge into the stave about ½ in. from the seam. If one wedge does not stop the leak drive another in the opposite stave at the same relative position.

Service Connections

These are made by tapping wood pipe with a brass nipple or service cock that is provided with a tapered wood thread on one end and a thread for a standard pipe on the other. The pipe is tapped by boring a hole at the point the connection is required. The proper size for the hole would be the diameter of the tapered end of the brass fitting, so that when it is screwed into position it will make a water-tight fit. Pipe should always be tapped in the solid wood and not in the seam between the staves. When tapping wood pipe under high pressure it is advisable to bore the hole to receive the service cock so as to leave a thin film of wood on the inside of the pipe. After the service cock is screwed into place the end will cut away the wood and allow the water to flow through the service cock (or use wood main drilling set).

Reinforced Inserted Joint Pipe

The only difference between standard joint pipe and reinforced inserted joint pipe is in the connection. The mortise end of standard inserted joint is banded with three or more wraps of wire, while the reinforced inserted joint is banded over the joint with one or more individual bands, thus allowing opportunity for adjustment.

Reinforced inserted joint pipe is laid the same as standard inserted joint, the only difference being that after the joint is driven home the band or bands are cinched slightly before the water is placed in the pipe. Great care should be exercised in tightening the bands. Where more than one band is used do not attempt to cinch one band to completion before the others, but cinch one, then the other until all are brought to a final cinch at the same time.

After the pipe line has been filled with water if there is excessive leakage at one joint the bands on this joint may be tight-

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ened slightly, but not necessarily enough to entirely overcome leakage. It is much better to give the wood a chance to swell, and stop leaking of itself, rather than to overcinch in an effort to stop the leakage at once. It is better to undercinch reinforced inserted joint pipe than to cinch it too tight at the beginning, and we therefore wish to strongly impress upon users the importance of using judgment in installing, and of carefully following these instructions.

Users are cautioned against handling wood pipe by running a stick into each end of the joint to use as a handle, thus causing excessive pressure on a small portion of the pipe and many times breaking out a piece of the tenon or the mortise, thus making it necessary to re-head the joint.

Engineers' Note Book

Capacity of Screw Conveyors

As a rough guide to approximate results in calculations on spiral conveyor, the diagram shown on the following page will prove of great value to all who deal with equipment of this class. The diagram cannot contain within its narrow limits all there is to be considered in spiral conveyor work, so its results must be applied with judgment, by the experienced—not followed blindly by the novice.

Section A is a conversion diagram for determining the equivalents of weights and volumes—tons and cubic feet per hour—for materials of various weights.

Section B takes the desired capacity in cubic feet per hour (or the equivalent in bushels per hour for grain only) and shows the size of spiral conveyor necessary for delivering that capacity at various rates of travel. The recommended range of travel rates for grain is indicated at the bottom of the diagram as from 130 to 160 ft. per minute; for heavy but non-abrasive materials, from 70 to 110 ft. per minute.

Section C gives the necessary rotative speed to enable the conveyor to deliver the desired capacity.

For example: Find size and speed of spiral conveyor for 40 tons of anthracite per hour. Anthracite weighs 55 lb. per cu. ft. Starting at the right side of section A of the diagram and following the diagonal for 40 (tons per hour) to the vertical of 55 (lb. per cu. ft.), and thence horizontally to the left we read 1500 cu. ft. per hour. Crossing to section B and following the diagonal upward into the range of travel speeds recommended for heavy non-abrasive materials, we find we have the choice between using a 12-in. conveyor with a travel speed of 105 ft. per minute, and a 14-in. conveyor with a travel speed of 75 ft. per minute. Here lies the opportunity for application of experienced judgment. We will use the 14-in. conveyor, and the easy travel speed of 80 ft. per minute. Following the vertical for this 80-ft. travel speed up to section C of the diagram we find, at the horizontal for 14-in. conveyor, that the necessary rotative speed is just under the diagonal for 70 r.p.m. The 12-in. conveyor at 105 ft. per minute travel speed would require a rotative speed of 105 r.p.m. In the lower rotative speed for the larger conveyor we find compensation for its extra size and cost.

Similarly, to carry 3500 bushels of grain per hour at a speed of 150 ft. per minute would call for a 16-in. conveyor, running 110 r.p.m.

Of course the methods above may be reversed to ascertain the capacity of a conveyor of given size, running at a stated speed.

The nature of the material, the sizes of its lumps, if any, the inclination of the conveyor box, and other modifying conditions must all be given consideration in application of diagram results to actual practice.

Spiral conveyor is not recommended for general use where there is apt to be much cutting action.

Diagram capacities are based on one-third the sectional area of the conveyor itself, and allowance accordingly must be made if the loading will not be fairly uniform. This is mainly a matter of power, as the horsepower increases very rapidly when the conveyor chokes up.

As a general formula for the horse-power for driving spiral conveyors the following is useful:

$$\text{Hp.} = C\ W\ L \div 33{,}000$$

wherein C = a constant; W = weight of material in pounds per hour; L = length of conveyor in feet. The value of the constant C is more variable than for almost any other type of conveyor, but for good conditions of operation it is safe to use 0.33 for grain, 0.65 for coal, and 1.0 for heavier and stickier materials.—*Webster Method.*

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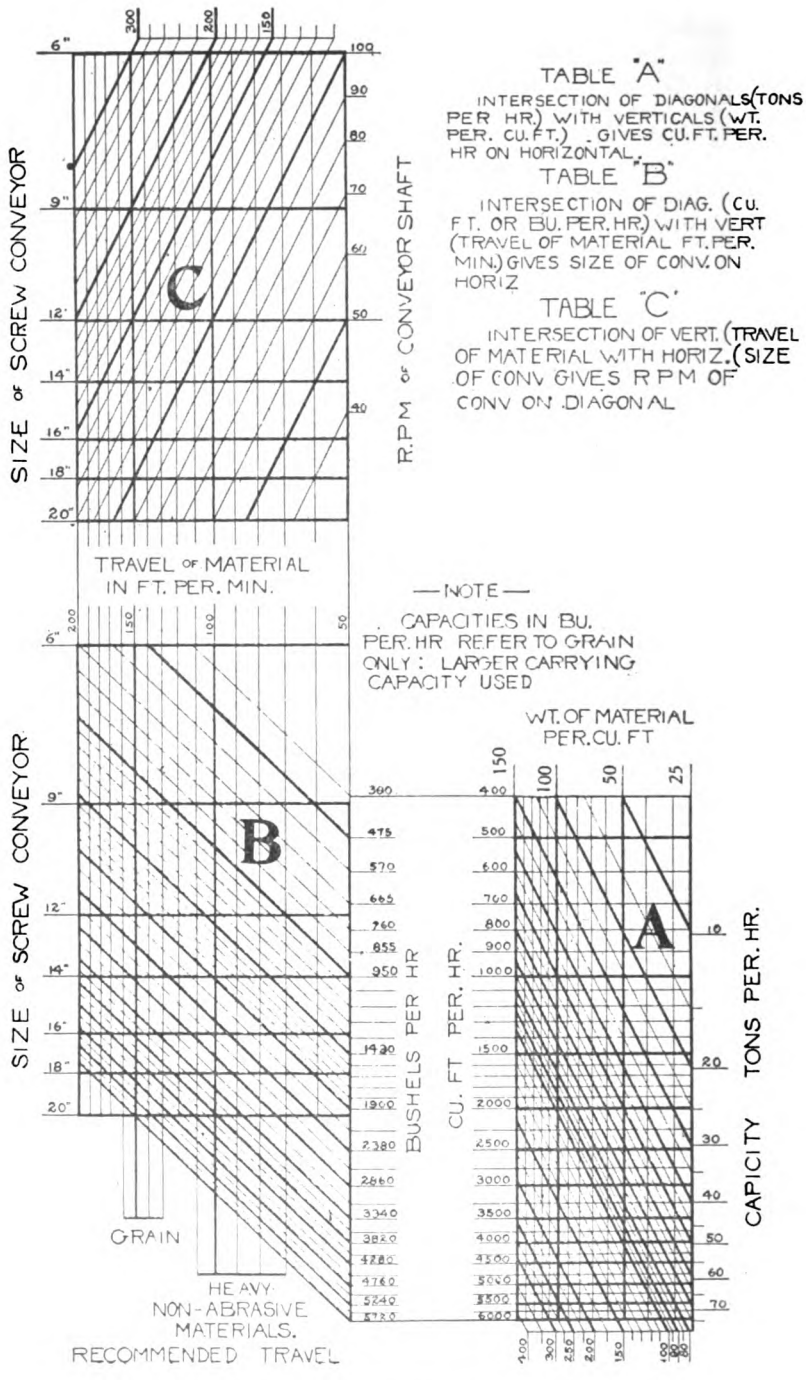
TABLE "A"
INTERSECTION OF DIAGONALS (TONS PER HR.) WITH VERTICALS (WT. PER. CU. FT.) GIVES CU. FT. PER. HR ON HORIZONTAL.
TABLE "B"
INTERSECTION OF DIAG. (CU. FT. OR BU. PER. HR.) WITH VERT (TRAVEL OF MATERIAL FT. PER. MIN.) GIVES SIZE OF CONV. ON HORIZ
TABLE "C"
INTERSECTION OF VERT. (TRAVEL OF MATERIAL WITH HORIZ. (SIZE OF CONV GIVES R P M OF CONV ON DIAGONAL
SIZE OF SCREW CONVEYOR
R.P.M. OF CONVEYOR SHAFT
TRAVEL OF MATERIAL IN FT. PER. MIN.
— NOTE —
CAPACITIES IN BU. PER. HR REFER TO GRAIN ONLY: LARGER CARRYING CAPACITY USED
WT. OF MATERIAL PER. CU. FT
BUSHELS PER HR
CU. FT PER. HR.
CAPICITY TONS PER. HR.
GRAIN
HEAVY NON-ABRASIVE MATERIALS.
RECOMMENDED TRAVEL

CAPACITY OF SCREW CONVEYORS.

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Book Reviews

FACTORY LIGHTING. By Clarence E. Clewell. McGraw-Hill Book Co., New York. P. 156. Index. For sale by the *Mining and Scientific Press*, San Francisco. Price, $2.

Once upon a time the term 'Factory District' was synonymous with darkness and dirt, and even today there are those who cling to the old idea that good workmanship and efficiency may be obtained in poorly lighted buildings. One of the greatest factors in producing better conditions among factory workers has been the introduction of the electric light. Lighting has gradually become a highly specialized profession, each specific case presenting individual problems for the illuminating engineer to solve. Mr. Clewell's work rightfully emphasizes the direct relation between scientific lighting and efficient, accurate work, and while the text is given over to artificial rather than natural lighting, the author has chosen that field to which ordinarily the lesser attention is paid. The economic as well as the engineering features come in for a good share of the discussion, while maintenance as well as first cost is considered in the data given. The general subject is treated under the subdivisions of Illuminating Design, Lighting Installation Work, Lighting Maintenance and Maintenance Records, Office Lighting, Drafting-room Lighting, Factory Lighting, Power-house Lighting, Iron and Steel Mill Lighting, and Machine Tool Lighting.

A TREATISE ON PETROLEUM. In three volumes. By Sir Boverton Redwood. J. B. Lippincott Co., Philadelphia. P. 1198. Bibliography. Index. For sale by the *Mining and Scientific Press*, San Francisco. Price, $15.

This is the third edition of this work, the first edition having appeared in 1895. With the petroleum-producing world as a field, some idea may be obtained of the monumental labor involved in the preparation of a work of this character. This is no mere reprint of a previous edition, as the entire text has been revised, rewritten, and added to, bringing the subject-matter up to present-day condition in the oil industry. The first volume is divided into sections as follows: Historical Account of the Petroleum Industry; Geological and Geographical Distribution of Petroleum and Natural Gas; Physical and Chemical Properties of Petroleum and Natural Gas; Origin of Petroleum and Natural Gas; Production of Petroleum, Natural Gas, and Ozokerite. The second volume covers Refining of Petroleum; Shale Oil and Allied Industries; Transport, Storage, and Distribution of Petroleum; Testing of Crude Petroleum, Petroleum, Shale-Oil Products, Ozokerite, and Asphalt; and the Uses of Petroleum and Its Products. The third volume covers Statutory, Municipal, and Other Regulations Relating to the Testing, Storage, Transport, and Uses of Petroleum and Its Products; Statistical Appendix; Marine Transport of Petroleum; Import Duties Levied in the United States; Petroleum and The Thames Conservancy. It is impossible to do justice in a limited space to a work of this character, as the book itself must be seen and read to be appreciated.

ASPHALT CONSTRUCTION FOR PAVEMENTS AND HIGHWAYS. By Clifford Richardson. McGraw-Hill Book Co., New York. P. 150. Index. For sale by the *Mining and Scientific Press*, San Francisco. Price, $2.

This is a pocket book for engineers, contractors, and inspectors, and as such should serve a useful purpose. The author as consulting engineer for the Barber Asphalt Co. has had an exceptional opportunity for the collection of data pertaining to this type of road construction. After describing the various materials used, comparative results obtained in various large cities are given. Maintenance and repair are discussed at length, while chapters on the plant, work on the street, advice to engineers, contractors, and inspectors, laboratory methods for the examination of materials, and instructions for taking samples complete the volume.

CONSERVATION OF WATER. By Walter McCulloh. Yale University Press, New Haven, Connecticut. P. 99. For sale by tne *Mining and Scientific Press*, San Francisco. Price, $2.15.

This work comprises a series of lectures delivered by the author before the senior class of the Sheffield Scientific School, Yale University. The data, therefore, are fundamental, and, although not placing before the engineering fraternity anything essentially new, constitute an excellent general

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presentation of the subject. The second chapter deals with the basic data essential to a comprehensive study of water storage; chapter three, water power; chapter four, water storage for water supplies, sanitation, and irrigation; and chapter five, water resources of New York state.

A TREATISE ON WOODEN TRESTLE BRIDGES AND THEIR CONCRETE SUBSTITUTES. By Wolcott E. Foster. John Wiley & Sons, New York. P. 430. Index. For sale by *Mining and Scientific Press*, San Francisco. Price $5.

This is the fourth edition of Mr. Foster's well known work, the first having been published in 1891. The latter part of the title is significant, and shows the author's recognition of the fact that concrete in various forms is making inroads in a field where wood has heretofore reigned supreme. While the subject matter is essentially applicable to railroad work, it actually takes in a much wider field. Trestle and bridge builders will find much data of value not only in railroad work but for wood supporting structures in general. Two new chapters have been added, one giving a short outline of timber preservation methods and the other on concrete trestles. An extensive bibliography of the subject has been appended and all chapters have been revised and enlarged.

THE IMPROVEMENT OF RIVERS, two volumes, by B. F. Thomas and D. A. Watt. John Wiley & Sons, New York. P. 713. Index. For sale by *Mining and Scientific Press*, San Francisco. Price, $7.50.

This is a big subject and one of vital importance wherever rivers exist. With the Dayton disaster fresh in our minds and in the memory of the many minor disasters, the time seems ripe for careful study of this subject. The concensus of opinion is that flood-control should be largely a function of the national government. It is eminently fitting therefore that the authors of this work are the principal assistant and assistant engineers, respectively, of the United States, and by reason of the vast amount of work already done by various government bureaus, have had an exceptional opportunity for the study of the many problems entering into this subject. This is the second edition of this work, the first, published in July 1902, having been rewritten and enlarged to embody advanced knowledge obtained during the last decade. The subject is treated in minute detail, in fact it is a veritable encyclopedia of data pertaining to every phase of river improvement. While much of the subject matter pertains to work done in the United States, the improvement of rivers in foreign countries is given due attention. Volume I treats of improvement by regulation, and is subdivided into chapters covering: Characteristics of Rivers; Regulation; Dredging and Snagging; Dikes; Protection of Banks; Levees; Storage Reservoirs; and the Improvement of Outlets of Rivers. Volume II treats of improvement by canalization and is subdivided into chapters covering: General Design and Construction of Locks and Dams; Locks; Lock Gates and Valves; Fixed Dams; Immovable Dams; Needle Dams; Chanoine Wicket Dams; Gate and Curtain Dams; Bridge and Shutter Dams; Drum Wickets, Bear Traps, and Rolling Dams; and Accidents to Structures.

Industrial Progress

Combined Standard Drilling Rig

By W. B. WIEGLE

The object of this invention is to provide means for working the casing and beam at the same time, to eliminate the danger of freezing the casing before the proper depth has been reached. To accomplish this it is necessary to place an extra engine in the derrick to operate both the calf wheel and bull wheel by means of chain drive to counter shaft and thence to bull and calf wheels. Both wheels are operated separately or together as desired by means of clutches and brakes for both wheels, and are conveniently arranged so that the driller can operate them while running the engine.

The casing is handled with a wire line sling 1⅞ in. diam. extending from the elevator over a yoke connected to casing blocks to spread the line to allow the beam to work between. The ends of the sling are attached by babbitt to sockets that connect to the elevator. One elevator is used for all sizes of casing by bushing from one to the other. A very simple and more con-

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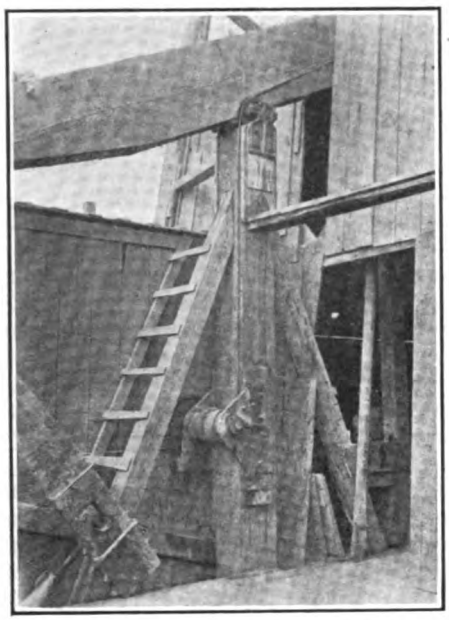
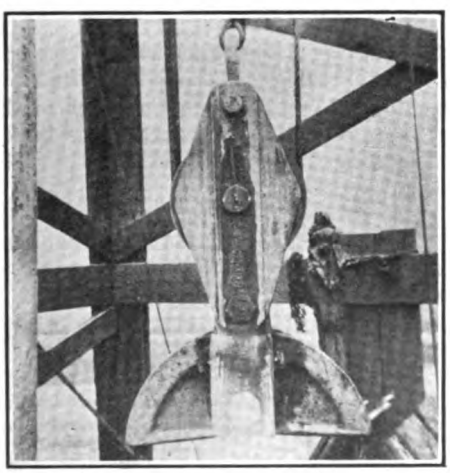
venient contrivance takes the place of the old temper screw.

One-inch wire lines are fastened to clamps



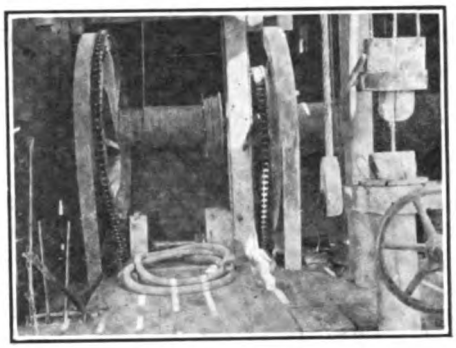
ROPE DRUM ATTACHED TO SAMPSON POST.

by babbitt and extend over pulleys on the end of the beam and held in place by a stirrup; then run back on each side of the



WIRE LINE SLING.

beam and over wheels on a saddle, thence down to a drum made fast to the Sampson post. The drum that takes up the line is fitted with a worm gear and shaft running into the derrick almost to the headache post and with a wheel on the end for the operator to pay out or take up the tools



CHAIN DRIVE FROM COUNTERSHAFT.

as desired. This gives plenty of room to work the casing from the floor to the end of the beam, and is very convenient in cleaning out and reaming, as 20 ft. can be let out if desired without hitching over. A patent was issued covering this device on May 16, 1911.

Company Reports

The Indio Light, Water & Ice Co. applied to the California Railroad Commission for authority to sell its property to H. E. Gard.

The Hemet-San Jacinto Gas Co. has applied for authority to issue $3000 in bonds for improvements upon its plant.

The California Railroad Commission has rendered a decision granting authority to A. A. Weber to sell to the Alta District Gas Company a gas plant serving the cities of Dinuba and Reedley, and authorizing the gas company to operate under franchises from the counties of Tulare and Fresno. The company was also given authority to issue its promissory notes in the sum of $20,000.

The California Railroad Commission has granted authority to H. H. Mayberry to sell a certain portion of a water distribution system in the city of Alhambra to J. A. Graves.

The California Railroad Commission has granted authority to the United Light & Power Company to issue a note in tne sum of $6000, for the purpose of purchasing neces-

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sary equipment to connect with the building owned by A. W. Kirkland in the city of Oakland.

The California Railroad Commission has granted authority to the Pacific Electric Railway Company to maintain and operate two wharves at Redondo beach.

The Davis Water Co. has filed an amended application for authority to issue 37,125 shares of its capital stock, of the par value of $1 per share.

The California Railroad Commission has granted authority to the Amador Electric Light & Power Co. to issue $12,000 of bonds to retire indebtedness and to issue 3000 shares of capital stock.

The United Light & Power Co. has applied for authority to issue a note in the sum of $6000 for an extension.

The California Railroad Commission has denied the Empire Water Co., of San Diego county, permission to issue $200,000 in bonds for the purpose of constructing a submerged dam near Coyote creek on the ground that the data presented in regard to the work were not sufficient to warrant the authorization of the securities issue. "Sufficient data have not been furnished on which a reasonably safe conclusion could be reached," says the Commission, "as to the successful development and impounding of a sufficient water-supply under the plan proposed to insure the success of the enterprise. While we do not conceive it to be the duty of this Commission to insist on complete proof of tne final success of an enterprise before permission will be given to the launching of the same, still we believe where the whole enterprise is to be financed on the sale of bonds, this Commission should be given information showing the feasibility of the enterprise." The Commission adds that individuals should not be restrained from expending their own money to finance the enterprise, but that the matter assumes a different phase when it is proposed to issue bonds to be sold to the public.

The California Railroad Commission has rendered a decision granting authority to the Sonoma Valley Water, Light & Power Co. to issue bonds to the amount of $30,000. The company proposes to use $9000 of these bonds to refund existing indebtedness, and will apply the balance in extending its system. The company supplies water to El Verano and vicinity in Sonoma county.

The Spring Valley Water Co. has applied to the California Railroad Commission for authority to issue $30,000 two-year 6% notes, secured by the deposit of $400,000 of the company's first-mortgage bonds. It was specified in the application that the proceeds of this issue were required for paying mortgages on watershed lands in Alameda county and for meeting indebtedness incurred in the construction of Calaveras dam. The company has authorized $28,000,000 of its 4% bonds, of which $17,859,000 is outstanding. $3,128,000 in the treasury, and $7,013,000 reserved for improvements, etc.

The *California Railroad Commission* has issued an order permitting the *Western Electric Co.* to sell its telephone exchange plant at Portola, Plumas county, California, to the Pacific Telephone & Telegraph Co. for $466.31.

The Atchison, Topeka & Santa Fe Railway has applied for permission to construct spur tracks at grade upon and across certain public highways in Fresno county, California.

The Lindsay Home Telephone & Telegraph Co. of California has been authorized to issue 1644 shares of its capital stock of the par value of $1644, said stock to be issued in exchange for property acquired by the company.

Western Pacific Railroad Co. has been granted authority to construct a track at grade across the track of the Sacramento Southern Railroad in the city of Sacramento, California.

The city of Riverside, California, which recently voted bonds in the sum of $1,160,000 for the acquisition of a municipal water system, has filed an application with the California Railroad Commission asking for authority to purchase the Riverside Artesian Water Co. for the sum of $195,000, and the water system of H. P. Kyes for the sum of $15,000, as portions of the system to be acquired.

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Engineering News

Petroleum

Dividends declared in August for California fields were as follows:

Amalgamated	$1.25	$62,500.00
Am. Pet. pfd.	0.50	8,255.50
do com.	0.33⅓	39,607.00
Home, Coalinga	0.01	10,000.00
Maricopa Queen	0.01	9,920.96
Mount Diablo	0.00½	5,000.00
Montebello	0.01	10,000.00
Pinal-Dome	0.00¼	9,000.00
Record	0.05	10,000.00
Rice Ranch	0.01	3,000.00
S. F.-McKittrick	0.01	5,000.00
Sauer Dough	0.01½	2,992.50
Section 25	0.25	10,000.00
State Con.	0.00½	2,500.00
W. Coast pfd.	1.50	15,000.00
Western Union	0.15	15,000.00
W. K.	0.02	10,000.00
Total		$1,352,775.96

California field production for August and September was as follows:

	August.	September.
Kern River	891,870	724,552
McKittrick	553,076	341,885
Midway	3,141,001	3,178,672
Sunset	530,720	465,048
Coalinga	1,604,561	1,511,374
Watsonville	2,325	.....
Belridge	.....	189,294
Lompoc	97,960	.....
Santa Maria	469,030	393,165
Summerland	5,160	4,350
Santa Paula	73,115	68,365
Newhall	11,020	11,383
Salt Lake	221,941	205,882
Los Angeles	29,929	26,905
Whittier-Coyote	261,123	341,474
Puente	2,480	.....
Fullerton-Brea Canyon.	649,663	514,575
Lost Hills	297,202	279,786
Salinas Valley	.....	.....
Repetto	.....	.....
Total	8,807,180	8,256,710

Streets and Roads

San Francisco, Cal.—The Board of Works is considering construction of a series of scenic boulevards around Twin Peaks.——The Great Highway along the ocean front is to be repaved.——The Mission Promotion Association has secured authority from the city for the extension of Potrero avenue from 25th street to Army street. This work will cost $13,916.65.——The board of supervisors has endorsed the application of the Eddy Street Improvement Association for repaving Eddy street from Taylor street to Van Ness avenue with asphalt.

Riverside, Cal.—The County Good Roads Commission has recommended an issue of $1,500,000 in bonds for the construction of new roads.

Pomona, Cal.—The proposal to issue bonds, providing $75,000 for new roads and $15,000 for fire apparatus has been ratified by the voters.

Imperial, Cal.—The county supervisors have decided to call an election for the purpose of issuing $500,000 in bonds for 34 miles of new county highways.

Alameda, Cal.—The City Council is considering calling an election for the purpose of issuing $500,000 worth of bonds for various street and other municipal improvements.

Richmond, Cal.—San Pablo avenue is to be paved from Stege Junction to the town of San Pablo. Warren H. McBride is supervisor in charge of this work.

Sacramento, Cal.—The State Highway Commission has ordered the following surveys: Section of 10½ miles between the western boundary of Riverside county and Riverside city; section of 5½ miles through Garberville, Humboldt county; section of 8 miles between Forsythe creek and Ridgewood, in Mendocino county.——A contract has been awarded to the Riverside Portland Cement Co. for 46,200 bbl. of cement, prices ranging from $1.58 to $2.10.

Marysville, Cal.—Arrangements have been made through Yuba county bankers to take state highway bonds to the value of $25,000, to provide funds for the construction of a new bridge over the Yuba river at D street to cost $120,000.

Salt Lake City, Utah.—The City Commission has awarded contracts for paving and sewer extension as follows: On a bid of $40,571.95, P. J. Moran was given the contract for paving extension 92, which takes in Highland drive from Twelfth South to Thirteenth South, a distance of about one mile. Other bidders and their bids were: J. W. Mellen, $44,569.26; A. A. Clark, $44,843.11.

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Strange & McGuire took paving extension 91 on a bid of $54,060.64. This improvement takes in Eleventh East street from Ninth South to Yale avenue, and thence east on Yale to Fifteenth East street. Other bidders were J. W. Mellen, $58,262.05; P. J. Moran, $59,313.03, and A. A. Clark, $63,975.26. Strange & McGuire were given the contract for paving extension 76 as well. This includes Second South street from Twelfth East to Elizabeth avenue. The bid was $1500 and was the only one entered. The Gilkerson Construction Co. was given a contract to lay sewers on the streets embraced in paving extension 91, on a bid of $8860.74. Other bidders were J. B. Mullins, $11,868.70; P. J. Moran, $12,348.50; Zerbe & Walker, $12,726.37.

Ogden, Utah.—The following bids were received for concrete pavement on Lincoln avenue between 26th and 30th streets: No guarantee, A. A. Clark, $14,750; P. J. Moran, $17,584.84; guaranteed work, A. A. Clark, $19,000; P. J. Moran, $18,417.85. Other bids were from $3000 to $5000 higher. In the opinion of J. H. Craven, the engineer, the property owners would prefer the non-guaranteed work. The paving is to be concrete. ——The City Commissions have decided that the Ogden Rapid Transit Co. must pave its tracks between 25th and 27th streets with asphalt instead of concrete.——Water-bound macadam road improvements and extensions will be continued during the winter.——M. Skeen is chairman of the Weber County Highway Commission.

Davenport, Washington.—The county commissioners have passed a resolution for the completion of 6 miles of highway between this city and Harrington at a cost of $30,000.

Pullman, Washington.—The city will issue $70,000 in 6% bonds to pay to the Warren Construction Co. for paving in districts 11, 12, and 13. It is stated that the work in districts 14 and 15 under construction by the Warren Construction Co. will be completed before the winter season.

Spokane, Washington.—A boulevard is recommended to be constructed around Ensign peak and 11th Avenue boulevard is also to be extended. George D. Keyser is Park Commissioner.——Appropriations have been made for the construction this year of North Wall street extension 7½ miles; South Moran, 8 miles; Market street extension, 1½ miles; and Sunset boulevard, 1 mile.——Bids have been asked for Market street extension north of Hillyard. The road will be constructed of bitu-crete on concrete, bitu-macadam, warrenite, bitu-mass, asphaltic concrete on macadam base, asphaltic concrete on concrete base, asphalt macadam, or macadam. The road will be 1.37 miles long, having a 16-ft. roadway with 4-ft. shoulders, giving a total width of 24 ft.——Contract has been awarded to C. M. Payne for paving Trent avenue from Division to Grand street with creosoted wood blocks at a cost of $28,600.

Walla Walla, Washington.—Contract has been awarded to the Atlas Construction Co. of North Yakima for the first five miles of the Walla Walla Waitsburg Highway, at a cost of $25,000.

Orient, Washington.—The Kettle River road is being surveyed for proposed improvements by B. N. Sharp, county engineer.

Olympia, Washington.—Contracts for various sections of state highway have been awarded to the amount of $140,000.——H. J. Doolittle, state engineer, will commence surveys near Colfax, on the northern section of the Inland Empire highway, including that portion of the north and south road between New Meadows and Grangeville on the east and west road from Olds Ferry to Montpelier on the Pan Handle National Highway line from Spokane bridge to Stregic pass.

Salmon, Idaho.—Preliminary survey of the proposed road from Gibbonsville to Bitter Root valley has been completed. C. M. Hull is county commissioner and Mr. Crandall is county surveyor.

Pocatello, Idaho.—An experimental road one mile in length will be built with sand and clay between Pocatello and Port Neuf. Mr. Smith is state engineer.

Boise, Idaho.—The State Highway Commission has adopted a plan for state highway work, calling for the following surveys: East and west highway, from Olds ferry on the Oregon-Idaho boundary line east through Weiser, Payette, Caldwell, Boise, Bliss, Hagerman, Twin Falls, American Falls, Pocatello, McCammon, Pebble, Montpelier, and Paris to Utah line. Western north and south highway, from Boise north via Long valley to New Meadows, Grangeville, Lewiston, Moscow, Coeur d'Alene to Sandpoint. Eastern north and south highway, from Idaho Falls northwest, following Birch creek to Gilmore, Salmon, and Crowfoot pass, connecting with Montana state highway. Spokane to Stregic Pass highway, from Spokane bridge east

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to Coeur d'Alene, Cataldo, Wallace, Mullan, linking Washington and Montana national highways. McCammon to Utah line, from McCammon south through Bannock and Oneida counties to Utah.

Irrigation and Water Supply

Richmond, California.—Engineer's estimates for city water supply call for the expenditure of $2,295,000, using wooden pipes; $2,880,000 using riveted steel pipes; and $4,980,000 using cast iron pipes. The proposed source is the Sacramento river at Collinsville, Solano county. Haviland, Dozier & Tibbetts of San Francisco are consulting engineers for the city.

Davis, California.—The Davis Water Co. will expend $25,000 immediately for the installation of a city water system. T. G. Schmeiser is president of the company.

Colusa, California.—The town trustees have agreed to purchase the Cooks Water Works at a cost of $4000.

Meridian, California.—The Tisdale ranch of the Sacramento river is to be placed under irrigation and subdivided into 40-acre tracts. A pumping station is to be installed at once. J. P. Massie & Sons of San Francisco are handling the project.

Oroville, California.—Harry Martin of San Jose, has purchased the 1400-acre Crain ranch and has placed a contract with W. Hemstreet of Marysville for sinking two wells. Pumping plants are to be installed. The property is to be placed under irrigation.

Orland, California.—The property owners have voted in favor of the extension of this project from 14,300 to 20,000 acres.——Bids have been received for the construction of the additional feed canal as follows: Hart Bros., Sacramento, $54,473; P. Schuyler, Oakland, $53,130; Maney Bros., Boise, Idaho, $72,950; and Shattuck-Edinger Co., Los Angeles, $87,325. E. G. Hopson, of the U. S. Reclamation Service, is chief engineer for this district.

Red Bluff, California.—The U. S. Reclamation Service has entered into a contract with the people of Tehama county to pay one-half of the estimated cost of $25,000 for surveying the Iron Canyon reservoir and irrigation project. J. M. Heister will be in charge of this work.——A bond election is to be called to provide $85,000 for the installation of a municipal water system.

Salt Lake City, Utah.—The Utah Conservation Co. is preparing plans for commencing work on proposed dam and ditches for the purpose of irrigating bench land lying between Ogden and Bountiful. Thomas R. Cutler is one of the directors——The Garfield Water Co. will expend $75,000 in improving the water supply for its mining property at Garfield.——The Thompson Co. of Salt Lake City has the contract for laying cast iron pipe.

Provo, Utah.—The Utah Lake Irrigation Co. has secured a loan of $250,000 for the extension of its irrigation system.

North Yakima, Washington.—The Selah Water Users' Association will expend $30,000 on various improvements before 1914. A reinforced concrete and steel pipe line is to be constructed for a distance of one mile.——The Congdon Irrigation district will build a new siphon.

Power, Gas, and Electricity

Fullerton, California.—The city has made a contract with the Birch Oil Co., operating in the Brea canyon, whereby the latter is to install a 6-in. pipe-line from its wells to a point one-half mile north of the city and furnish natural gas at a cost of 20c. per 1000 cu. ft. The city will install a receiving tank and distribution system at a cost of about $30,000. A bond issue is to be called to provide funds for this purpose.

Fresno, Cal.—The Pacific Light & Power Corporation of Los Angeles reports a damage of $10,000 by fire to its plant No. 2 at Big Creek.——The Napa Valley Electric Co. of Napa has applied for permission to issue forty-one $500 bonds and other securities to provide funds for extensions and improvements. F. W. Meilenz is general manager.

Oroville, California.—A project is under way for the installation of a 60,000-hp. hydroelectric power-plant at the middle fork of the Feather river. The plant is estimated to cost $360,000. L. F. Breuner, F. G. Eby, and S. H. Whisner of Sacramento are promoting the project.

Woodland, California.—The Winters Gas Co. has been incorporated for the purpose of maintaining and operating a city gas plant at the town of Winters. C. A. Erwin, Allan Stark, and W. W. Collins of Winters are handling the project.

Klamath Falls, Oregon.—A municipal power-plant is to be installed on Link river. Negotiations for water rights between the

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U. S. Government and the state are under way.

Spokane, Washington.—City council will employ an expert in an advisory capacity for the proposed municipal lighting plant installation; $5000 having been appropriated to pay for this work. William C. Ross of Spokane and Burns & MacDonnell of Kansas City are applicants for the position.——Plans and specifications for the proposed luminous arc curb lighting system for Riverside avenue have been filed with C. M. Fassett, city commissioner. The estimated cost is $27,625.50.

Pomeroy, Washington.—The Pacific Power & Light Co. has applied to the city council for a 50-year lighting and power franchise.

Ogden, Utah.—The breaking of a valve on the water power pipe-line of the Utah Light & Railway Co. has damaged the power-plant to an extent estimated to be between $50,000 and $100,000.

Boise, Idaho.—The Idaho Power & Light Co. has acquired the holdings of the Beaver River Power Co. in Boise and southern Idaho at a cost of approximately $1,000,000. A new corporation has been organized under the laws of Nevada, by the Idaho Power & Light Co. The main offices are in Boise. L. L. Nunn is president of the new company. E. P. Bason is general manager.

Moscow, Idaho.—It is stated that the Washington Water Power Co. is planning extensions to the company's power lines from Palouse to Moscow.

Miscellaneous Engineering Construction

Long Beach, California.—A company is being organized for the erection of a reinforced concrete pier and other improvements at a cost of $100,000. S. G. Barker, F. J. Greene, and W. H. Underwood are interested in the project.

Los Angeles, California.—A petition has been filed with the Board of Supervisors by the North Highland Park Improvement Association for the installation of a sanitary sewer system.

San Francisco, California.—The Board of Harbor Commissioners has advertised for proposals to construct a 7-stall round-house for the use of the Belt railway.——It is stated that the construction of the Chipps Island bridge will be commenced within thirty days. Twenty months will be required for its completion. The bridge will be more than 12,000 ft. long. The Oakland, Antioch & Eastern railroad is handling the project.

Richmond, California.—The city council has ordered engineers to prepare specifications for the construction of the training wall and bulkhead for the Inner Harbor Improvement project.

Sacramento, California.—The city council is preparing plans for a special election for issuing $900,000 in bonds for new schools. ——Two new bridges are to be built across the American river at 12th street and Walnut Grove at a cost of $83,000 each.——The city commissioners have awarded a contract to the Southern Pacific Co. for levee construction, at a total cost of $300,000.

Colusa, California.—Contract has been awarded for repairs to the levee opposite Princeton to Peart & Sanders of Grimes, at a cost of about $500,000.

Napa, California.—The city council has decided to call for a bond election to provide $12,000 for the purchase of a fire automobile, $9000 for storm sewers, $22,000 for a new stone bridge, and $70,000 for a city hall site and building.

Redding, Cal.—Contract for a steel bridge across Clear creek near French Gulch has been awarded to William Stevens at a price of $1571.

Salt Lake City, Utah.—Plans have been completed and submitted to R. P. Morris, commissioner of streets, for a new sewer system. Estimated cost is $250,000. L. H. Krebs is city sewer engineer.

Brigham City, Utah.—N. L. Morris, of Salt Lake City, is planning the establishment of a concrete pipe factory at this point.

Provo, Utah.—Construction work has commenced on the Provo Lake resort pier which is being built by the city.

Spokane, Washington.—The Spokane River-Hangman Creek bridge for the Oregon-Washington Railroad & Navigation Co. has been completed. J. O. Barr was engineer in charge of construction. The cost was $450,000, and the structure is 3003 ft. long and 203 ft. from the foundation to the highest point. Total weight of steel is 3900 tons. The Kelly-Atkinson Co. had the contract for the steel construction work. J. W. Strack, county engineer, has decided to use concrete for all bridge work required in future highway improvements in preference to any other material.

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Railways

San Francisco, California.—The Railroad Commission has granted permission to the Sacramento Valley Electric Co. to spend $1000 per month for organization and promotion work.——The city engineer has stated that all plans and specifications for the municipal street railroad, for which $3,500,000 was provided in a recent bond issue, will be ready to turn over to bidders as soon as the funds are available.——An extension is planned by the Northwestern Pacific Electric Railroad from Fairfax to the new townsite of Manor.——Charles S. Swan, 1023 Mills building, has applied to the board of supervisors for the right-of-way for an elevated railroad from the Ferry depot to the Exposition grounds.——San Rafael & San Anselmo Valley Railway Co. has applied for permission to issue $100,000 in stock and $100,000 in bonds for the purpose of constructing and operating a street railroad through San Rafael, San Anselmo, and Fairfax. Storage-battery cars will be used. S. J. Norton is handling the enterprise.

Richmond, California.—Castro Point Railroad will resume construction, as right-of-way disputes have been settled.

Seattle, Washington.—The city council has voted to accept the proposal of the Seattle, Renton & Southern railroad for the purchase of its property by the city for $1,200,000. The portion conveyed at this price is that lying within the city limits. An option has been given for the purchase by the city of the balance of the system at $200,000 any time up to September 1, 1917.

Boise, Idaho.—It is stated that work will be commenced immediately for the construction of the Altour Creek railroad in Kootenai county. The directors of the company are L. W. Butler of Lane, A. E. Cole of Cataldo, F. B. Foltz of Kellogg, Idaho; W. R. Jaquis of Pullman, Washington, and G. N. Butler of Spokane.——The Boise & Winnemucca railroad has completed surveys. H. H. Sheldon, of Caldwell, is preparing the field data.

Lewiston, Idaho.—Construction work has been commenced on the Johnson railroad, which is being built by Z. A. Johnson, from Lewiston *via* Tammany to Vollmer.

Denver, Colorado.—The Moffat Tunnel Commission has placed a contract with Newman Erb for the bore through James peak. The tentative estimate of cost is $4,500,000, of which the city will pay $3,000,000 through a bond issue recently authorized. The control of water, power, and electricity through the tunnel is in the hands of the Denver Public Utilities Commission.

Salt Lake City, Utah.—It is stated that the Denver & Rio Grande railroad has applied for right-of-way for an extension between Price and Huntington in Carbon and Emery counties.

Spokane, Washington.—The following estimate by J. R. Holman, chief engineer of the Oregon-Washington Railroad & Navigation Co., shows the cost of contemplated improvements at this point.

Union Passenger Station:

Excavation and filling	$ 5,700
Concrete	48,400
Granite, stone, and brick	82,300
Reinforcing steel and metal	28,500
Structural steel	46,200
Tile, marble, and terrazza	28,200
Plumbing and heating	44,000
Ornamental iron and sashes	45,000
Plastering, painting, glazing	41,000
Sheet metal work	19,800
Mill and carpenter work	20,000
Elevators and scales	17,600
Electric lighting fixtures, wiring, and hardware	21,800
Furniture and fittings	31,000
Paving and sidewalks	5,500
Miscellaneous items	38,000
	$523,000
Add 10%, engineering and contingencies	52,300
Total	$575,300

Viaduct, Post to Center Streets:

Excavation and filling	$ 75,000
Concrete	103,000
Structural steel	518,000
Platforms and waterproofing, umbrella sheds	55,000
Miscellaneous	15,000
	$ 766,000
Add 10%, engineering and contingencies	76,600
Total	$ 842,600
Grand total	$1,417,900

All of the above work is between Center and Post streets.

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Personal

W. R. HAMILTON has removed his offices to 433 California street, San Francisco.

JOHN T. WHISTLER is assistant engineer for the Iron Canyon Irrigation project near Red Bluff.

ROWE POWELL has been appointed superintendent of the Seaboard Oil & Transit Co., succeeding E. J. Johnson.

EDWARD ST. CLAIR SMITH has been appointed state highway engineer for the state of Idaho, with headquarters at Boise.

W. H. KIRKBRIDE, division engineer for the Southern Pacific Co., is in charge of the repair of the Sacramento city levees.

ARTHUR F. L. BELL, chief engineer for the Associated Oil Co., has been inspecting the company's property in the Lost Hills district.

SYLVESTER Q. CANNON, city engineer for Salt Lake City, has been inspecting the Utah rock asphalt fields in the vicinity of Sunnyside.

W. M. MEEK, city engineer for Marysville, California, has prepared plans for a new concrete bridge across the river opposite Marysville.

A. YOST has been appointed superintendent for the Brea Canyon Oil Co. in the Fullerton field, succeeding WILLIAM FERRAND, who has resigned.

J. F. ENWRIGHT has been appointed superintendent of motive power at the Sacramento, California, shops of the Western Pacific Railroad Company.

R. R. LYMAN, professor of civil engineering at the University of Utah, attended the sessions of the National Highway Association at Detroit, Michigan.

E. A. PORTER, district engineer for the U. S. Geological Survey, has returned to Salt Lake City from an inspection trip through Humboldt county, Nevada.

E. J. JOHNSON has resigned his position as superintendent of the Gate City Oil Co. to accept a similar position with the Alberta Midway Oil Co. in the Midway field.

J. M. HEISTER, engineer for the U. S. Reclamation Service in the state of Nevada, will take charge of the preliminary surveys for the Iron Canyon reservoir irrigation project near Red Bluff, California.

R. P. MCLAUGHLIN, consulting petroleum geologist, has been appointed by the California State Mining Bureau to conduct a comprehensive compilation of data pertaining to all phases of the California oil industry.

FRANK P. KING, state engineer for Idaho, THEODORE TURNER of Pocatello, and W. E. PATRIE of Blackfoot have been appointed by the Governor to act as a commission to supervise the work and traffic on the Ross Fork road.

JOHN F. ELLISON, of Red Bluff, is president; W. A. BEARD, of Marysville, first vice-president; DAVID BROWN, of Orland, second vice-president; A. L. CONRAD, of Red Bluff, secretary; and T. H. RAMSEY, of Red Bluff, treasurer for the Iron Canyon Project Association.

Obituary

RUDOLPH DIESEL died some time between September 29 and 30, having accidentally drowned by falling overboard from the channel steamer *Dresden* en route from Antwerp to London, where he was to attend a meeting of the English Diesel engine company. His death marks the passing of one of the notable figures in mechanical engineering, and the universal regret at his tragic end is tempered by the fact that he lived long enough to enjoy the fruits of his genius and to be accorded the recognition that was his just due.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

of Western Engineering, published monthly at San Francisco, California, required by the Act of August 24, 1912.

Name of	Postoffice Address.
Editor:	
Chas. T. Hutchinson,	San Francisco, Cal.
Managing Editor:	
Chas. T. Hutchinson,	" " "
Business Manager:	
L. A. Greene,	" " "
Publisher:	
Western Engineering Publishing Co.,	" " "
Owners: (If a corporation, give names and addresses of stockholders holding 1 per cent or more of total amount of stock.)	
Dewey Publishing Co.,	San Francisco, Cal.
H. Foster Bain,	" " "
H. W. Baker,	" " "
H. F. Dexter,	" " "
L. A. Greene,	" " "
Chas. T. Hutchinson,	" " "
Jno. J. Young,	" " "
Edgar Rickard,	London, England
T. A. Rickard,	" "

Known bondholders, mortgagees, and other security holders, holding 1 per cent or more of total amount of bonds, mortgages, or other securities: None.

CHAS. T. HUTCHINSON, Editor.

Sworn to and subscribed before me this 27th day of September, 1913.

(Signed) HENRY B. LISTER,
Notary Public in and for the City and County of San Francisco, State of California.
(My commission expires February 1st, 1914.)

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